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EARLIER PHOTOGRAPHY OF THE FIRMAMENT.

CHARLES NEVERS HOLMES.

It is unfortunate that astro-photography, even in a less perfected development, could not have been employed by Sir William Herschel and other astronomers of his time or before. Perhaps this is very much like saying, "If *only* Handel or Haydn could have lived in these days of magnificent organs!" Had the art of photography been discovered in the eighteenth instead of the nineteenth century, what advancements would have been made, years ago, in astronomical science! We of this twentieth century might *now* be understanding many sidereal mysteries that we shall not understand in our generation nor, it may be, in the next generation.

Man, indeed, has always carried around with him, at some time during his life, a personal photograph—although that photograph was wholly meaningless. The tanning by the Sun of his skin is a kind of photography, although it was not suggestive enough to lead to the invention of the dry plate. Of course some unknown person, more a dreamer than a practical man, saw dimly or even clearly the fundamentals of photography, long, long before it was discovered. Every day we speak of such and such an individval as *the* discoverer of some valuable scientific secret, whereas the real discoverer has been dead and buried for centuries. But the practical discoverer should be praised, for, had he not announced his discovery, it might have remained for years hidden from mankind. And, with respect to photography, we are less interested in him who *may* have been the first discoverer than in him who announced publicly that pictures could be taken by means of light-rays.

It was as far back as 1824 that Louis Jacques Mandé Daguerre began experiments as *the* pioneer in photography. Previous to this date Wedgwood and Davy had obtained prints of ferns and other objects by placing them on paper which had been treated with silver nitrate and then exposing them to the light. Later, Daguerre formed a sort of partnership with Joseph Nicéphore Niepce and in 1839 they announced the discovery of photography, of which the principle had been foreseen by Daguerre in 1832. The process as then employed consisted in exposing a metal plate covered with silver iodide for 20 minutes in a photographic camera, afterwards placing this plate in vapor of mercury which developed the latent image, which was made permanent by immersion in a solution of sodium chloride.

This great discovery was announced on August 10, 1839, and at a meeting of the French Academy or Sciences in Paris, on August 19, Daguerre gave a demonstration of what was popularly called "sun-pictures." Very naturally he named his discovery after himself, the "Daguerreotype process." Of course the scientific men of that day were wildly enthusiastic over this remarkable discovery, and people hurried to Paris in great numbers to hear and learn about it. The French government awarded Daguerre an annual life pension of about $1200 —which represented then a far larger sum than it would today—and afterwards gave out his important discovery to the world. Most of us have seen "Daguerreotypes", and remember how crude and somewhat unsatisfactory they were, being merely an image photographed upon a copper plate, an image which could be seen distinctly only when looked at in a certain direction. It must have been rather tiresome work having one's picture taken by the first daguerreotype photographers, as it required an exposure of fully thirty minutes!

News of this discovery by Daguerre spread rapidly for those times around the world, the information reaching the United States the same year through Samuel F. B. Morse, famous himself as the practical discoverer of the telegraph. By him it was communicated to his colleague, John W. Draper, of New York University, who made the first sunlight picture of a human face, in 1840. Of course it was not long, since the new discovery was taken up so energetically and universally, before the crudeness of the original process was greatly improved, in England by men like Fox-Talbot, Scott-Archer and Dr. Maddox and in America by Draper, Morse and Langenheim. From the "Daguerreotype" were developed the "Calotype process", then the "wet-plate process", and finally the "Dry-plate method" which, improved and further developed, is known to all of us today.

It was only a natural step from terrestrial light-pictures to celestial light-pictures. Indeed, in 1839, the very year when Daguerre announced

his discovery, M. Arago, in speaking before the Academy of France, referred to the possibilities of photography in assisting astronomical science. Hardly had the first photographic studios been opened (1840) when Dr. Draper was successful in taking the Moon's photograph by the Daguerreotype process. As was to be expected, this first lunar photograph was not remarkable in appearance, being only one inch in diameter. Even then, Dr. Draper had great difficulty in obtaining it, after hundreds of attempts and exposures. However, he was more successful than Daguerre had been in 1838 when he tried to photograph the Moon.

Then, as now, our Moon under certain conditions presented an appearance very tempting to an astronomer with a camera. But for about ten years after Dr. Draper's comparative success there did not seem to be any marked advance in lunar photography. Finally, at the great London Exhibition of 1851, there were on exhibition fair photographs of the Moon. In 1850 Professor Bond, of the Harvard Observatory, had secured with a 15-inch refractor a lunar Daguerreotype, one that for the first time showed a distinct image. It was sent to the London Exhibition, the next year, and caused a great sensation and interest. In 1853 Mr. Warren de la Rue took several good photographs of the Moon, and with improvements in photography and telescopes astronomers have been able to obtain better and more instructive lunar photographs. However, what wonderful and spectacular photographs of our Moon *may* be taken within the coming half-century!

After trying to take photographs of the Moon man turned his attention to photography of the Sun. This was, of course, far more difficult, the first attempt in that direction being by Foucault and Fizeau at Paris in 1845, who followed the suggestion of Arago. In 1851 there occurred the earliest success in solar photography—a Daguerreotype of the Sun's prominences which was obtained by Berkowsky. Six years later Warren de la Rue was commissioned by the Royal Society to devise an instrument for photographing the Sun, to be placed at Kew Observatory in England. The photo-heliograph that he constructed was a small telescope of 3½-inch aperture and 50-inch focus. It had a plate-holder attached to the eye-piece, protected in front by a spring-slide whose rapid movements across the field provided practically an instantaneous exposure for the sensitive plate, this arrangement being necessary owing to the powerful light of the Sun. By means of this instrument the first solar pictures of value were taken, and a photographic record of solar conditions was established—a record that was continued at Kew Observatory from 1858 to 1872. Nevertheless, it was not until the year 1869 that a total eclipse of the Sun was satisfactorily photographed, by Professor Stephen Alexander.

Then, after taking photographs of objects belonging to his own solar system, man began to point his telescope-camera towards the remote suns of night.

As in the case of lunar and solar photography, the progress of stellar photography was slow, although Bond and Whipple obtained light-pictures of Castor and Vega as far back as about the year 1850. Then, in 1872 and 1873 Rutherfurd in New York took excellent photographs of the beautiful cluster of the Pleiades. Since that time until now what tremendous progress has been accomplished by light, lens and plate in revealing the former mysteries of our firmament—and yet what a stupendous task the telescopic camera has before it! Nevertheless, so far, many great advances have been made along the illimitable highway of the Universe, or, it may be, only *one* of many universes. There is the discovery of our occasional neighbor Eros, to which we were introduced not long ago by the silent testimony of the sensitive plate. Today we gaze with wonderment and awe at the latest specimens of firmamental photographic art, and ponder upon how vast have been the results from such a crude and small beginning. Although not comparable with the delight of standing directly beneath the open dome of the darkened heavens, there is in this indirect representation of the star-lighted sky no little suggestion of its real magnificence. There are the wide, dead surface of the Moon, the dazzling face of the Sun, Saturn and its rings, the sun-dotted sky of night, and the nebulae which may lie far, far beyond the confines of the remote "Milky Way", depicted by the action of truthful light-rays against the blackness of a recording negative. Were Louis Daguerre to return to Earth and to behold the marvellous results accomplished by celestial photography—without seeing the terrestrial results—he would be wholly overwhelmed. And yet the astronomical scientists of today have probably never experienced any more intense enthusiasm over some new discovery amid sidereal realms—and perhaps not as much enthusiasm—than the members of the French Academy of Sciences felt way back in that first glimmering dawn of photography, on August 19, 1839.

Newton, Mass.
41 Arlington St.

THE LUNAR SAROS.

WILLIAM F. RIGGE.

In speaking of the Saros, that period of 18 years 10 or 11 days (according as 5 or 4 leap years intervene) 7 hours and 42 minutes, after which eclipses repeat themselves in the same order and with very nearly the same circumstances, text-books of astronomy generally confine themselves to solar eclipses and call attention to the 7 hours and 42 minutes, which shift an eclipse track about 120 degrees of longitude farther west at each recurrence. Such a restriction can bring with it only a theoretical interest and consign its applications to the technical computers of solar eclipses. It can be of no practical utility to the ordinary student or non-professional, since only a very small percentage of solar eclipse tracks can fall during that period in a country even as large as the United States.

In lunar eclipses, however, the case is reversed. Not only are more than fifty per cent of them visible in any one place, but their circumstances can be more plainly seen and studied, their magnitude, time, and nearness of the Moon's path to the shadow's center can be compared, and the whole subject brought down more closely and interestingly within the grasp of the ordinary lover of astronomy.

This thought lately came home forcibly to the writer when it struck him that two complete Saroses of lunar eclipses had run by since he first began his study of them in 1883. As he had made graphical constructions of all the 32 lunar eclipses that were visible more or less since that year in the United States, it was a comparatively easy task to complete the series by inserting the remaining eclipses. With two Saroses of lunar eclipses entire before him, it was then an interesting study to arrange the similar or conjugate eclipses, to examine the constancy of the interval between them as well as the interval between successive eclipses, and to compare the magnitudes and all other circumstances.

Just as he was about to present his findings to the reader, the writer bethought himself of a better plan. This was to take all the lunar eclipses in the complete series of the American Ephemeris from the year of its inception in 1855. But as the Creighton University Observatory was founded only in 1885 and its series of the Ephemeris does not extend beyond that year while that of the St. Louis University, St. Louis, is complete, Professor John B. Goesse very kindly and care-

TABLE I

Elements of the Lunar Eclipses in the American Ephemeris

No.	Year	Date	Central Time: Conjunction	Central Time: Mid-Eclipse	Magnitude	Moon N or S	Least Distance	Declination of Shadow	Radii of: Umbra	Radii of: Penumbra	Radii of: Moon	Radii of: Sun	Moon's ourly Motion	Slope of Moon's Path	Duration of Totality	No.
								° ′	″	″	″	″	″	° ′	h m	
1 A	1855	May 1	9:57 PM	10:05 PM	1.549	607 N	555	15 12 S	2533	4479	936	954	1847	−23 47	1 36	1
B	1873	May 12	5:10 AM	5:20 AM	1.437	835	781	18 13	2525	4467	931	952	1834	20 43	1 31	
C	1891	May 23	12:19 PM	12:29 PM	1.306	1064	1017	20 20	2519	4453	928	948	1823	17 6	1 20	
D	1909	June 3	7:19 PM	7:29 PM	1.164	1306	1272	22 20	2508	4438	925	946	1810	13 2	1 2	
2 A	1855	Oct. 25	1:18 AM	1:29 AM	1.464	864 S	777	11 57 N	2678	4653	979	968	2025	+26 0	1 29	2
B	1873	Nov. 4	9:40 AM	9:51 AM	1.430	944	886	15 33	2686	4666	979	971	2035	23 27	1 27	
C	1891	Nov. 15	6:09 PM	6:19 PM	1.393	996	935	18 38	2694	4675	981	971	2046	20 12	1 24	
D	1909	Nov. 27	2:46 AM	2:55 AM	1.372	1021	980	21 3	2700	4685	983	973	2053	16 16	1 22	
3 A	1856	Apr. 20	3:42 AM	3:07 AM	0.712	2216 S	1988	11 39 S	2371	4324	891	957	1672	−26 12		3
B	1874	May 1	10:31 AM	10:03 AM	0.833	1938	1772	15 10	2371	4415	890	952	1666	23 52		
C	1892	May 11	5:15 PM	4:53 PM	0.959	1654	1546	18 39	2367	4305	888	950	1660	20 47		
D	1910	May 23	11:49 PM	11:34 PM	1.099	1357	1296	20 36	2365	4297	887	947	1653	17 10	0 51	
4 A	1856	Oct. 13	5:21 PM	4:54 PM	0.998	2004 N	1774	8 8 N	2785	4753	1004	965	2147	+27 43		4
B	1874	Oct. 25	1:39 AM	1:17 AM	1.053	1849	1663	12 5	2785	4755	1004	966	2149	25 54	0 34	
C	1892	Nov. 4	10:04 AM	9:45 AM	1.100	1713	1572	16 9	2783	4758	1004	968	2149	23 19	0 46	
D	1910	Nov. 16	6:36 PM	6:21 PM	1.131	1604	1506	18 44	2781	4761	1004	971	2150	20 2	0 52	
7 A	1858	Feb. 27	3:26 PM	4:14 PM	0.331	3232 N	2863	8 11 N	2558	4539	945	971	1888	−27 40		7
B	1876	Mar. 9-10	11:30 PM	12:21 AM	0.298	3390	2972	3 57	2573	4544	948	966	1902	28 45		
C	1894	Mar. 21	7:27 AM	8:21 AM	0.248	3500	3060	0 36 N	2587	4551	950	963	1915	29 3		
D	1912	Apr. 1	3:20 PM	4:14 PM	0.187	3635	3191	3 39 S	2601	4560	953	960	1928	28 36		
8 A	1858	Aug. 24	7:38 AM	8:20 AM	0.482	2780 S	2422	11 7 S	2449	4391	910	952	1798	+29 23		8
B	1876	Sept. 3	2:32 PM	3:22 PM	0.348	3094	2718	7 12	2438	4380	908	952	1747	28 34		
C	1894	Sept. 14	9:36 PM	10:32 PM	0.231	3323	2909	3 4 S	2425	4373	905	955	1726	28 55		
D	1912	Sept. 26	4:45 AM	5:45 AM	0.122	3536	3090	1 11 N	2414	4369	903	958	1716	29 4		

9	A	1859	Feb.	17	4:38	AM	4:43	AM	1.691	384	N	345	12	5	N	2732	4716	991	973	2090	−25	58	1	38	9
	B	1877	Feb.	27	1:09	PM	1:15	PM	1.617	525		465	8	4		2743	4717	993	968	2099	27	46	1	37	
	C	1895	Mar.	10	9:31	PM	9:39	PM	1.627	572		501	3	50	N	2752	4720	995	966	2106	28	50	1	36	
	D	1913	Mar.	22	5:48	AM	5:58	AM	1.575	700		612	0	30	S	2729	4724	996	963	2114	29	7	1	33	
10	A	1859	Aug.	13	10:34	AM	10:34	AM	1.828	15	N	13	14	43	S	2356	4294	882	950	1636	+24	13	1	46	10
	B	1877	Aug.	23	5:07	PM	5:10	PM	1.761	269	S	241	11	11		2345	4283	882	950	1634	26	30	1	39	
	C	1895	Sept.	3	11:48	PM	11:57	PM	1.557	532		469	7	17		2341	4283	882	952	1632	28	7	1	41	
	D	1913	Sept.	15	6:34	AM	6:48	AM	1.435	781	S	683	3	9		2318	4286	882	955	1633	29	1	1	34	
11	A	1860	Feb.	6	8:55	PM	8:29	PM	0.812	2323	S	2131	15	34	N	2770	4759	1002	975	2135	−23	27			11
	B	1878	Feb.	17	5:39	AM	5:11	AM	0.840	2318		2038	11	56		2771	4752	1002	971	2183	28	28			
	C	1896	Feb.	28	2:15	PM	1:46	PM	0.871	2283		2020	7	16		2770	4745	1001	968	2133	27	47			
	D	1914	Mar.	11	10:43	PM	10:13	PM	0.916	2203		1930	3	39		2768	4739	1000	966	2128	28	48			
12	A	1860	Aug.	1	11:59	AM	11:28	AM	0.443	2662	N	2483	17	51	S	2396	4330	896	948	1689	+21	8			12
	B	1878	Aug.	12	6:43	PM	6:08	PM	0.596	2439		2177	14	48		2404	4338	898	948	1737	26	49			
	C	1896	Aug.	23	1:32	AM	12:57	AM	0.735	2212		1981	11	16		2410	4347	900	950	1705	26	25			
	D	1914	Sept.	4	8:27	AM	7:55	AM	0.864	1988		1755	6	49		2417	4359	902	952	1714	28	2			
15	A	1861	Dec.	17	2:11	AM	2:18	AM	0.185	2924	N	2918	23	23	N	2362	4357	894	978	1679	− 3	43			15
	B	1879	Dec.	28	10:08	AM	10:24	AM	0.164	3000		2967	23	18		2358	4351	893	976	1685	8	28			
	C	1898	Jan.	7	6:10	PM	6:35	PM	0.157	3040		2960	23	7		2352	4344	891	976	1666	13	13			
	D	1916	Jan.	20	2:05	AM	2:40	AM	0.137	3134		2988	20	23		2348	4337	890	975	1660	17	33			
16	A	1862	June	12	12:20	AM	12:21	AM	1.200	1385	S	1383	23	9	S	2794	4721	1001	945	2141	+ 1	44	1	3	16
	B	1880	June	22	7:45	AM	7:50	AM	1.071	1642		1632	23	27		2796	4726	1004	946	2144	6	15	0	39	
	C	1898	July	3	3:07	PM	3:17	PM	0.933	1959		1941	23	28		2801	4727	1002	944	2129	7	48			
	D	1916	July	14	10:30	PM	10:46	PM	0.800	2271		2193	21	36		2803	4729	1003	944	2150	14	58			
17	A	1862	Dec.	6	1:40	AM	1:40	AM	1.415	700	N	699	22	30	N	2322	4310	883	975	1632	− 2	18	1	32	17
	B	1880	Dec.	16	9:37	AM	9:38	AM	1.388	736		738	23	22		2320	4316	886	978	1632	3	18	1	30	
	C	1898	Dec.	27	5:38	PM	5:42	PM	1.384	766		757	23	31		2325	4316	884	976	1636	8	30	1	29	
	D	1917	Jan.	8	1:38	AM	1:45	AM	1.369	806		785	22	18		2329	4320	885	976	1638	13	12	1	29	
18	A	1863	June	1	5:24	PM	5:26	PM	1.224	1314	N	1312	22	6	S	2757	4687	991	946	2098	− 2	26	1	7	18
	B	1881	June	12	12:55	AM	12:54	AM	1.365	1060		1059	23	10		2732	4663	987	947	2109	+ 1	57	1	22	
	C	1899	June	23	8:20	AM	8:18	AM	1.488	791		786	23	13		2744	4670	987	944	2078	+ 6	26	1	30	
	D	1917	July	4	3:42	PM	3:39	PM	1.625	703		692	22	41		2736	4662	985	944	2066	+10	22	1	37	

TABLE I CONTINUED.

No.	Year	Date	Central Time: Conjunction	Central Time: Mid-Eclipse	Magnitude	Moon N or S	Least Distance	Declination of Shadow	Radii of: Umbra	Radii of: Penumbra	Radii of: Moon	Radii of: Sun	Moon's Hourly Motion	Slope of Moon's Path	Duration of Totality	No.
															h m	
19 A	1863	Nov. 25	2:56 AM	2:56 AM	0.956	1604″ S	1596″	20° 42″ N	2437″	4422″	913″	973″	1754″	+ 5° 34′		19
B	1881	Dec. 5	11:07 AM	11:08 AM	0.979	1561	1561	22 28	2442	4435	918	977	1787	+ 1 12		
C	1899	Dec. 16	7:29 PM	7:26 PM	0.996	1539	1537	23 21	2452	4443	918	976	1773	− 3 32		
D	1917	Dec. 28	3:54 AM	3:46 AM	1.011	1532	1516	23 18	2461	4452	920	976	1783	− 8 21	0 17	
20 C	1900	June 12	9:31 PM	9:28 PM	0.003	3499 N	3499	22 13 S	2565	4489	939	943	1870	+ 1 24		20
D	1918	June 24	4:40 AM	4:28 AM	0.135	3252	3231	22 32	2553	4479	936	944	1857	6 30		
22 A	1865	Apr. 10	11:09 PM	10:38 PM	0.196	2999 S	2878	8 19 S	2348	4300	885	957	1643	−16 20		22
B	1883	Apr. 22	6:08 AM	5:38 AM	0.086	3170	3069	12 11	2345	4295	884	956	1640	14 33		
C	*1901*	*May 3*	*12:56 PM*	*12:31 PM*	*−0.025*	*3350*	*3277*	*15 38*	*2349*	*4287*	*883*	*951*	*1639*	*12 0*		
D	*1919*	*May 14*	*7:30 PM*	*7:10 PM*	*−0.145*	*3534*	*3492*	*18 34*	*2346*	*4288*	*884*	*951*	*1641*	*8 54*		
23 A	1865	Oct. 4	5:07 PM	4:40 PM	0.344	3239 N	3090	4 38 N	2786	4747	1003	961	2145	+17 26		23
B	1883	Oct. 16	1:21 AM	12:54 AM	0.280	3347	3213	8 48	2774	4744	1003	965	2141	16 15		
C	1901	Oct. 27	9:39 AM	9.15 AM	0.228	3425	3319	13 39	2777	4748	1002	966	2139	14 18		
D	1919	Nov. 7	6:04 PM	5:44 PM	0.184	3472	3401	16 12	2772	4749	1001	969	2093	11 37		
24 A	1866	Mar. 30	10:39 PM	10:33 PM	1.420	553 S	529	4 4 S	2363	4322	890	960	1660	−17 1	1 37	24
B	1884	Apr. 10	5:54 AM	5:47 AM	1.441	723	694	8 12	2364	4320	891	957	1675	16 14	1 33	
C	1902	Apr. 22	1:01 PM	12:53 PM	1.338	909	880	12 19	2382	4328	894	954	1679	14 29	1 27	
25 A	1866	Sept. 24	8:12 AM	8:07 AM	1.617	530 N	505	0 31 N	2677	4630	973	957	2020	+17 42	1 37	25
B	1884	Oct. 4	4:08 PM	4:02 PM	1.533	684	653	4 47	2664	4623	970	960	1998	17 20	1 33	
C	1902	Oct. 17	12:10 AM	12:03 AM	1.464	812	780	8 55	2651	4615	968	963	1988	16 6	1 27	
26 A	1867	Mar. 20	2:29 AM	2:49 AM	0.813	2031 N	1934	0 17 N	2538	4502	932	963	1837	−17 45		26
B	1885	Mar. 30	10:16 AM	10:34 AM	0.886	1891	1800	3 29 S	2534	4492	935	960	1820	17 44		
C	1903	Apr. 11	5:57 PM	6:13 PM	0.973	1722	1652	8 10 S	2538	4483	938	957	1863	16 23		
27 A	1867	Sept. 13	6:04 PM	6:26 PM	0.704	2211 S	2109	3 42 S	2486	4434	921	955	1792	+17 30		27
B	1885	Sept. 24	1:27 AM	1:48 AM	0.790	2030	1938	0 33 N	2466	4419	918	957	1780	17 21		
C	1903	Oct. 6	8:59 AM	9:17 AM	0.868	1862	1760	4 18 N	2459	4418	916	960	1787	19 6		

30 A	1869	Jan.	27	7:52 PM	7:38 PM	0.458	2871 S	2832	18	13	N	2750	4737	997	974	2112	− 9	26			30
B	1887	Feb.	8	4:40 AM	4:22 AM	0.436	2936	2865	14	12		2745	4729	995	973	2106	12	39			
C	1905	Feb.	19	1:23 PM	1:00 PM	0.410	3017	2913	10	28		2732	4710	994	970	2053	15	4			
31 A	1869	July	23	8:12 AM	8:02 AM	0.566	2336 N	2320	20	1	S	2439	4367	906	945	1723	+ 6	52			31
B	1887	Aug.	3	3:05 PM	2:49 PM	0.424	2622	2580	16	43		2447	4377	909	946	1744	10	17			
C	1905	Aug.	14	10:04 PM	9:41 PM	0.292	2905	2821	14	18		2456	4390	911	948	1754	13	9			
32 A	1870	Jan.	17	8:47 AM	8:46 AM	1.664	367 S	365	20	42	N	2585	4576	953	976	1923	− 5	35	1	39	32
B	1888	Jan.	28	5:22 PM	5:20 PM	1.647	389	384	18	8		2570	4558	951	974	1912	9	25	1	38	
C	1906	Feb.	9	1:50 AM	1:47 AM	1.631	428	418	14	55		2568	4551	948	972	1900	12	35	1	38	
33 A	1870	July	12	4:34 PM	4:34 PM	1.687	357 S	356	21	55	S	2627	4553	956	944	1958	+ 2	54	1	41	33
B	1888	July	22	11:44 PM	11:45 PM	1.825	92 S	91	20	0		2633	4560	959	945	1958	6	50	1	42	
C	1906	Aug.	4	7:01 AM	7:00 AM	1.786	170 N	167	17	22		2649	4579	962	946	1970	10	17	1	42	
34 A	1871	Jan.	6	3:15 PM	3:14 PM	0.693	2039 N	2039	22	28	N	2397	4388	903	976	1714	− 1	11			34
B	1889	Jan.	16	11:23 PM	11:30 PM	0.702	2030	2020	20	42		2384	4374	901	976	1705	5	33			
C	1907	Jan.	29	7:26 AM	7:38 AM	0.711	2017	1989	18	9		2364	4371	899	974	1699	9	29			
35 A	1871	July	2	7:29 AM	7:27 AM	0.349	3075 S	3075	23	4	S	2768	4706	997	944	2123	− 1	11			35
B	1889	July	12	2:50 PM	2:54 PM	0.486	2811	2807	22	39		2785	4710	998	944	2128	+ 3	6			
C	1907	July	24	10:14 PM	10:22 PM	0.620	2562	2542	19	56		2790	4717	1000	945	2134	+ 7	5			
37 A	1872	May	22	4:47 PM	5:18 PM	0.121	3605 N	3447	20	35	S	2714	4651	981	950	2049	−17	3			37
B	*1890*	*June*	*3*	*12:20 AM*	*12:45 AM*	*−0.011*	*3600*	*3510*	*22*	*19*		*2701*	*4630*	*988*	*946*	*2039*	*12*	*50*			
38 A	1872	Nov.	14	10:38 PM	11:19 PM	0.030	3583 S	3363	18	35	N	2481	4476	927	973	1815	+20	13			38
B	1890	Nov.	26	7:01 AM	7:34 AM	0.015	3557	3413	20	1		2501	4486	930	973	1825	16	17			
C	*1908*	*Dec.*	*7*	*3:31 PM*	*3:55 PM*	*−0.001*	*3522*	*3445*	*22*	*39*		*2510*	*4497*	*933*	*974*	*1836*	*11*	*53*			

TABLE II.

Intervals Between Successive and Conjugate Eclipses.

No.	A				B				C				D			A	B	C	D	No.
				h m				h m				h m								
1	1855	May	1	7 15	1873	May	12	7 9	1891	May	23	7 0	1909	June	3	1.549	1.437	1.306	1.164	1
	176	3	24	+1 7	176	4	31	+1 19	176	5	50	+1 36	176	7	26					
2	1855	Oct.	25	8 22	1873	Nov.	4	8 28	1891	Nov.	15	8 36	1909	Nov.	27	1.464	1.430	1.393	1.372	2
	178	1	38	−1 26	178	0	12	−1 38	177	22	34	−1 55	177	20	39					
3	1856	Apr.	20	6 56	1874	May	1	6 50	1892	May	11	6 41	1910	May	23	0.712	0.833	0.959	1.099	3
	176	13	48	+1 26	176	15	14	+1 38	176	16	52	+1 55	176	18	47					
4	1856	Oct.	13	8 23	1874	Oct.	25	8 28	1892	Nov.	4	8 36	1910	Nov.	16	0.998	1.053	1.100	1.131	4
5																				5
	501	23	20	−0 15	501	23	5	−0 29	501	22	36	−0 43	501	21	53					
6																				6
7	1858	Feb.	27	8 7	1876	Mar.	9-10	8 0	1894	Mar.	21	7 53	1912	Apr.	1	0.331	0.298	0.248	0.187	7
	177	16	6	−1 5	177	15	1	−0 50	177	14	11	−0 40	177	13	31					
8	1858	Aug.	24	7 2	1876	Sept.	3	7 10	1894	Sept.	14	7 13	1912	Sept.	26	0.482	0.348	0.231	0.122	8
	176	20	23	+1 30	176	21	53	+1 14	176	23	7	+1 6	177	0	13					
9	1859	Feb.	17	8 32	1877	Feb.	27	8 24	1895	Mar.	10	8 19	1913	Mar.	22	1.691	1.617	1.627	1.575	9
	177	5	51	−1 57	177	3	54	−1 36	177	2	18	−1 28	177	0	50					
10	1859	Aug.	13	6 46	1877	Aug.	23	6 47	1895	Sept.	3	6 51	1913	Sept.	15	1.828	1.761	1.557	1.435	10
	177	9	55	+2 6	177	12	1	+1 48	177	13	49	+1 36	177	15	25					
11	1860	Feb.	6	8 42	1878	Feb.	17	8 35	1896	Feb.	28	8 27	1914	Mar.	11	0.812	0.840	0.871	0.916	11
	176	14	55	−1 58	176	12	57	−1 46	176	11	11	−1 29	176	9	42					
12	1860	Aug.	1	6 43	1878	Aug.	12	6 49	1896	Aug.	23	6 58	1914	Sept.	4	0.443	0.596	0.735	0.864	12
13																				13
	502	14	54	+1 21	502	16	15	+1 23	502	17	38	+1 8	502	18	45					
14																				14
15	1861	Dec.	17	8 6	1879	Dec.	28	8 11	1898	Jan.	7	8 5	1916	Jan.	20	0.185	0.164	0.157	0.137	15
	176	22	2	−0 36	176	21	26	−0 44	176	20	42	−0 36	176	20	6					
16	1862	June	12	7 29	1880	June	22	7 27	1898	July	3	7 29	1916	July	14	1.200	1.071	0.934	0.800	16
	177	1	19	+0 29	177	1	49	+0 37	177	2	25	+0 34	177	2	59					
17	1862	Dec.	6	7 58	1880	Dec.	16	8 4	1898	Dec.	27	8 3	1917	Jan.	8	1.415	1.388	1.384	1.369	17
	177	15	46	−0 31	177	15	15	−0 39	177	14	36	−0 42	177	13	54					
18	1863	June	1	7 28	1881	June	12	7 24	1899	June	23	7 21	1917	July	4	1.224	1.365	1.488	1.625	18
	176	9	30	+0 45	176	10	15	+0 53	176	11	8	+0 59	176	12	7					

19	1863	Nov.	25	8	12	1881	Dec.	5	8	18	1899	Dec.	16	8	20	1917	Dec.	28	0.956	0.979	0.996	1.011	19
											178	2	2	−1	20	178	0	42					
20											1900	June	12	7	0	1918	June	24			0.003	0.135	20
	502	19	42	−1	12	502	18	30															
21											501	11	47	+1	29	501	13	16					22
22	1865	Apr.	10	7	0	1883	Apr.	22	6	53	*1901*	*May*	*3*			*1919*	*May*	*14*	0.196	0.086	*−0.025*	*−0.145*	22
	176	18	2	+1	14	176	19	16															
23	1865	Oct.	4	8	14	1883	Oct.	16	8	21	1901	Oct.	27	8	29	1919	Nov.	7	0.344	0.280	0.228	0.184	23
	177	5	53	−1	0	177	4	53	−1	15	177	3	38										
24	1866	Mar.	30	7	14	1884	Apr.	10	7	6	1902	Apr.	22						1.420	1.441	1.338		24
	177	9	34	+0	41	177	10	15	+0	55	177	11	10										
25	1866	Sept.	24	7	55	1884	Oct.	4	8	1	1902	Oct.	17						1.617	1.533	1.464		25
	176	18	41	−0	9	176	18	32	−0	22	176	18	10										
26	1867	Mar.	20	7	45	1885	Mar.	30	7	29	1903	Apr.	11						0.813	0.886	0.973		26
	177	15	37	−0	23	177	15	14	−0	10	177	15	4										
27	1867	Sept.	13	7	18	1885	Sept.	24	7	39	1903	Oct.	6						0.704	0.790	0.868		27
28																							28
	502	1	12	+1	22	502	2	34	+1	9	502	3	43										
29																							29
30	1869	Jan.	27	8	44	1887	Feb.	8	8	38	1905	Feb.	19						0.458	0.436	0.410		30
	176	12	24	−1	57	176	10	27	−1	46	176	8	41										
31	1869	July	23	6	47	1887	Aug.	3	6	52	1905	Aug.	14						0.566	0.424	0.2 2		31
	178	0	44	−1	47	178	2	31	−1	35	178	4	6										
32	1870	Jan.	17	8	34	1888	Jan.	28	8	27	1906	Feb.	9						1.664	1.647	1.631		32
	176	7	48	−1	23	176	6	25	−1	12	176	5	13										
33	1870	July	12	7	11	1888	July	22	7	15	1906	Aug.	4						1.687	1.825	1.786		33
	177	22	42	+1	3	177	23	45	+0	53	178	0	38										
34	1871	Jan.	6	8	16	1889	Jan.	16	8	8	1907	Jan.	29						0.693	0.702	0.711		34
	176	16	11	−0	47	176	15	24	−0	40	176	14	44										
35	1871	July	2	7	27	1889	July	12	7	28	1907	July	24						0.349	0.486	0.620		35
36	325	9	51																				36
						501	16	30	*+1*	*3*	*501*	*17*	*33*										
37	1872	May	22	*7*	*27*	*1890*	*June*	*3*			679	21	6						0.121	*−0.011*			37
	176	6	1																				
38	1872	Nov.	14	8	15	1890	Nov.	26	*8*	*21*	*1908*	*Dec.*	*7*						0.030	0.015	*−0.001*		38
	178	6	1	−1	6	178	4	55	*−1*	*12*	*178*	*3*	*43*										
1	1873	May	12	7	9	1891	May	23	7	0	1909	June	3						1.437	1.306	1.164		1

fully supplied all the desired data anterior to 1885. In this way the series here presented was made to embrace 101 eclipses and to extend over three and a half Saroses.

Table I shows the eclipses grouped appropriately. The first column gives an arbitrary serial number, No. 1 A, being the first eclipse in the Ephemeris. The letters A, B, C, D, designate the conjugate eclipses under each number. The second column gives the year and the date and the next two the central times of the Moon's conjunction in right ascension with the Earth's shadow and of the Middle of the Eclipse when the Moon's center was nearest the shadow's centre. After the column of magnitudes, we find the seconds of arc that the Moon's center passed north or south of the shadow's centre, with the least distance at mid-eclipse adjoining. Next to the declination of the centre of the shadow at conjunction, we find the radii or semi-diameters of the umbra, penumbra, Sun and Moon in seconds of arc, followed by the Moon's hourly motion in its relative path and the slope of the latter as referred to a circle of declination, and finally the duration of the total eclipses.

If we study this table carefully, in fact even at a first glance at it, we will be struck by the remarkable similarity of the circumstances of the conjugate eclipses, grouped under each number. The magnitudes of the eclipses, the sizes of the umbra, penumbra, Sun and Moon, indeed all the circumstances, even those of the times which we shall study later, show such remarkable and gradual transitions that, except in a few critical cases, we might be tempted to jump at the conclusion that the prediction of eclipses was a matter of mere arithmetic.

Table II emphasizes the item of the time intervals between eclipses, which is not evident in Table I. The columns A, B, C, D give the years and dates of the conjugate eclipses with their serial numbers at the left and right margins. The narrow columns between the dates give the interval between the conjugate eclipses in hours and minutes in excess of 6585 days, that is 18 years 10 or 11 days, according as 5 or 4 leap years intervene. This interval is the Saros. Thus the interval between the conjugate eclipses of 1855 May 1 and 1873 May 12, or between 1A and 1B, is 6585 days 7 hours and 15 minutes. The next conjugate eclipse 1C comes 6585 days 7 hours and 9 minutes later, and 1D 6585 days 7 hours and 0 minutes later. We see at once that the length of the Saros as given in text-books, 6585 days 7 hours 42 minutes, can be only a mean length.

Figure 1 shows this feature graphically. The numbers 6, 7, 8, 9 are the hours in excess of 6585 days, and the dots are the actual hours and minutes between conjugate eclipses for their mean dates. Thus the mean date between 1859 May 1 and 1873 May 12, or 1A and 1B,

is May 6, and the interval is 7 hours and 15 minutes as remarked above. In Figure 1 a dot will be found on May 6 at 7 hours 15 minutes. The line at 7 hours 42 minutes is the mean length.

The series of dots connected by full lines belong to the intervals between the A and B eclipses in our list, while those connected by the dotted lines belong to the intervals between the B and C eclipses. We see that the curves are nearly alike and about ten days apart. This shows that the position of the curve does not depend on the seasons, but is gradually shifted along the year. The reason for its shape we must leave to the analytic mathematician. A third curve showing the intervals between the C and D series has been omitted from Figure 1, because it would congest it too much. It was drawn on a

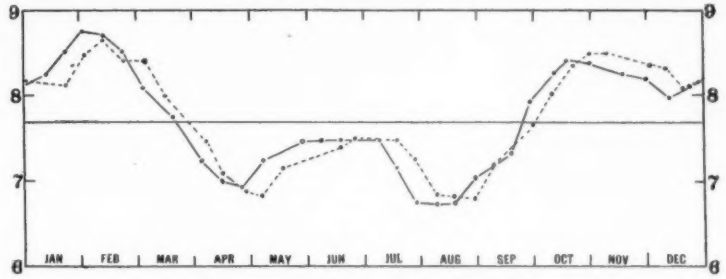


FIG. 1. ACTUAL LENGTHS OF THE SAROS.

trial figure and found to have the same shape and to show the same shift. About half of it had to be plotted by filling up the narrow columns between C and D from No. 24 to 38 by interpolation. For the same reason, that is, to avoid crowding the figure, the conjugate dots were not connected.

In Table II, the numbers in the vertical columns between the dates, such as 176 3 24 between 1A and 2A, 1855 May 1 and 1855 October 25, are the intervals in days, hours and minutes between successive eclipses, and the numbers between these in the narrow columns such as +1 7, show the increase or decrease of this interval in the conjugate eclipses. Although a graphic plot of these intervals between successive eclipses did not disclose a simple law, their variation, like that between the conjugate ones, is easily seen to be remarkably regular.

The intervals between successive eclipses seem to occur in sets of five, of from about 176 to 178 days, interrupted by about 501 or 502 days. This latter is roughly three times 176 and is broken up into 325 and 176, roughly twice and once 176, between Nos. 35A and 38A. This shows us how the gradual variations of the circumstances of the eclipses may cause a series of conjugate eclipses to run out or to begin. In the

first case, as is well shown in 22A and 22B in Table II, 1865 April 10 and 1883 April 22, the Moon dips less and less into the Earth's shadow, so that the magnitudes shown in the last four columns to the right gradually diminish and change to minus, if that expression may be allowed and made to mean the distance, in terms of its own diameter, that the Moon misses the shadow. These latter are, of course, not eclipses. They are placed in our Table II for the sake of this explanation, and to distinguish them are printed in *italic figures*. They are only four, 22C, 22D, 37B and 38C. When a magnitude is very small numerically, as — 0.001 in 1908 December 7, this close approach is called an Appulse.

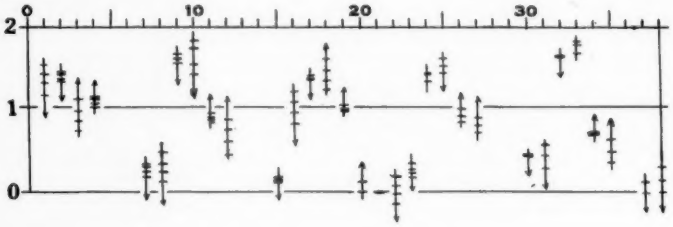


FIG. 2. VARIATIONS OF THE MAGNITUDES.

Figure 2 shows this in a graphic way. The numbers in the upper part are the serial numbers of the eclipses. Those on the left, 0, 1, 2, are the magnitudes, 1 being just total, and 0 meaning an appulse or geometric contact. The short lines with the arrow heads give the magnitudes of the conjugate eclipses and the direction of their growth. Thus for No. 1, we may identify the magnitudes 1.549, 1.437, 1.306, 1.164 and see that they are decreasing. Nos. 7, 8, 15, 22, 23, 31, 37, 38, show outgoing series. No. 20 is the only noticeable incoming one. These would undoubtedly be more numerous and probably fill up all the blank numbers, if a greater number of Saroses could have been drawn from. Where no arrowhead is attached, the magnitude has passed its maximum and is beginning to diminish.

The reader is specially cautioned not to entertain the idea that eclipses may be predicted by means of Tables I and II only. The reason for presenting these tables at all, and for writing this article, was to attempt to treat in a popular form a subject that is of its very nature very intricate and mathematical, and to answer in a way intelligible to a nonprofessional the question asked of every astronomer, how eclipses are predicted. While the arithmetical method as shown in these two tables can claim to be only approximate, the most technical computer of eclipses will admit that they save him at least half the labor of the computation.

With Table I open before us, it will be of interest to note a few details. In examining the column of magnitudes, we find that the greatest was 1.828* in 10A and occurred in 1859 August 13, the greatest possible magnitude being 1.898. The least distance between the centers of the Moon and the shadow was only 13″ and happened, of course, at this same eclipse, which also had the longest duration of totality, 1 hour 46 minutes. The shortest duration of totality was 17 minutes, during the eclipse of 1917, December 28 in 19D, which gained its totality by nearly three times as large a margin as its mate 19C of 1899 December 16 missed it. The greatest size of the umbral radius, 2803″, occurred in 1916 July 14, 16D, and the least 2318″, in 1913 September 15, 10D. The greatest penumbral radius, 4761″, happened in 1910 November 16, 4D, the least, 4283″ in 1877 August 23 and 1895 September 3, 10B and 10C. The possible variations of the radius of the shadow lie between 2808″ and 2312″, and that of the penumbra between 4766″ and 4271″, all of which were closely approached. The maximum semi-diameter of the Moon was 1004″ in 1880 June 22, 16B, and in the group of No. 4; the least, 882″, in the group of No. 10. The size of the Sun's semi-diameter varied between 978″ and 944″, the hourly motion of the Moon in its relative path between 2183″ and 1632″, and its slope between 29° 23′ in 1858 August 24, 8A and 1° 11′ in 34A and 35A.

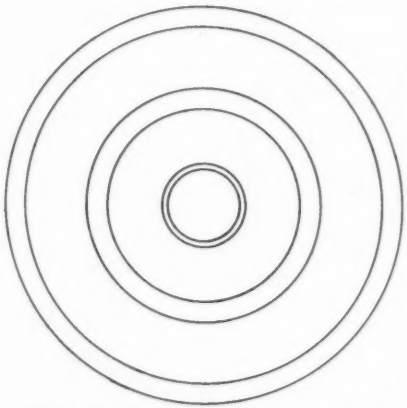


FIG. 3. MAXIMUM AND MINIMUM COMPARATIVE SIZES OF THE MOON, UMBRA AND PENUMBRA.

Figure 3 shows graphically the maximum and minimum comparative sizes of the Moon, the umbra and the penumbra in the inner, middle and outer pairs of circles respectively. The maximum and minimum values of these, however, do not occur simultaneously in the same eclipse, nor are they proportional.

* The Ephemeris gives 1.181 which is evidently a misprint.

THE PATH OF THE MOON'S SHADOW.

FREDERIC R. HONEY.

A close approximation to the form of the moon's shadow which is cast upon the earth during a total eclipse of the sun may be determined graphically. The problem is to find the intersection of the surface of a moving cone with that of a rotating spheroid, the axis of which is inclined to the plane of its orbit, the general direction of rotation being the same as that of the motion of the cone. During the period of an eclipse—only a few hours—the earth moves in its orbit a small fraction of a degree; and as a consequence the variation of the angle which the projection of its axis forms with the plane of the ecliptic between the beginning and end of an eclipse is inappreciable in a drawing of these dimensions. The length of the moon's shadow is determined by the formula

$$L = \frac{Dr}{R-r}$$

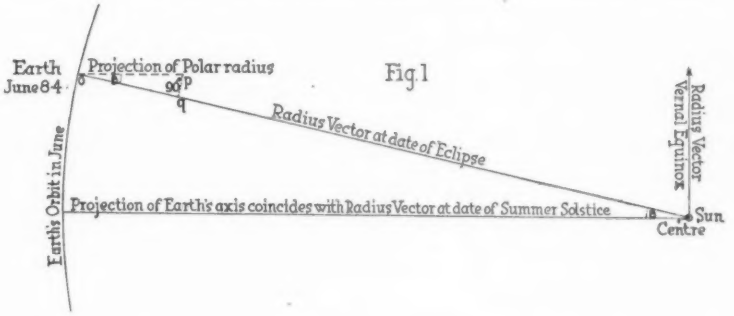
in which D is the distance between the sun and the moon, and R and r their radii.

Since details of construction would confuse the illustrations, they are omitted in the drawings, as for example in Figure 2, where it is required to construct the projections of parallels the latitudes of which are known; and also of parallels and meridians through given points on the earth's surface.

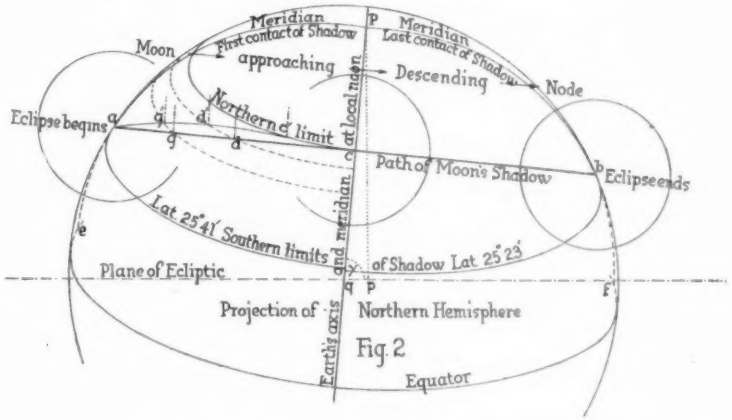
The total eclipse of the sun which will occur on June 8, 1918, which will be visible in the United States, affords an excellent illustration. The shadow will cross the illuminated portion of the earth's surface in a little over three hours; and since it will begin and end in latitudes which will differ only by three tenths of a degree, it may be considered as composed of two parts which will be very nearly symmetrical. Also the most northerly point will be on a meridian which will be very nearly midway between those which will contain the first and last points of contact with the earth. The first part will extend from latitude 25° 41′ to latitude 50° 51′ in one hour and 35.2 minutes; and the second part to latitude 25° 23′ in one hour and 35.5 minutes. During this short period of time the moon's motion in its orbit may be treated as uniform in a drawing of these dimensions.

Figure 1 represents the earth's radii vectors at the dates of the eclipse and of the summer solstice. The angle (β) between them is

equal to the angle between the projection of the earth's axis on the plane of the ecliptic and the radius vector. The projection of the polar


Earth June 84
Projection of Polar radius
Fig. 1
Radius Vector at date of Eclipse
Radius Vector Vernal Equinox
Earth's Orbit in June
Projection of Earth's axis coincides with Radius Vector at date of Summer Solstice
Sun Centre

radius is equal to its true length multiplied by the cosine of the angle (66° 33′) which it forms with the plane of the ecliptic. This part of the figure is drawn to the same scale as Figure 2, which is a projection of the northern hemisphere on a plane perpendicular to the radius vector. The angle (γ) of inclination of the projected axis is found as



follows: Make $qp = qp$ (Fig. 1), and pP equal to the length of the polar radius multiplied by the sine of 66° 33′. Or it may be found analytically. Let 66° 33′ = θ, and the polar radius = unity. Then

$$op \text{ (Fig. 1)} = \cos\theta; \text{ and } pP \text{ (Fig. 2)} = \sin\theta.$$

Also

$$pq \text{ (Fig. 1)} = \sin\beta\cos\theta$$

But

$$\tan \gamma = \frac{pP}{qp} = \frac{\sin \theta}{\sin \beta \cos \theta} = \frac{\tan \theta}{\sin \beta}.$$

At the date of the summer solstice

$$\beta = 0° \text{ and } \frac{\tan \theta}{\sin \beta} = \infty; \text{ i.e. } \gamma = 90°.$$

The projection of the axis is perpendicular to the plane of the ecliptic. At the date of the vernal equinox

$$\beta = 90°, \text{ and } \tan \gamma = \tan \theta; \text{ i.e. } \gamma = \theta$$

The angle θ is projected in its true value because its plane is parallel to the plane of projection.

The meridian $P\,a\,e$, part of which is invisible, crosses the parallel (lat. 25° 41′) at a, the first point of contact; and the meridian $P\,b\,f$, part of which is also invisible, crosses the parallel (lat 25° 23′) at b, the last point of contact. At c the shadow reaches the parallel (lat. 50° 51′), the most northerly point, which is on the meridian at local noon, the projection of which coincides with that of the earth's axis.

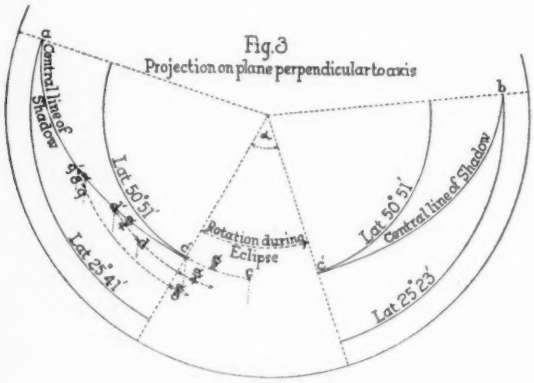
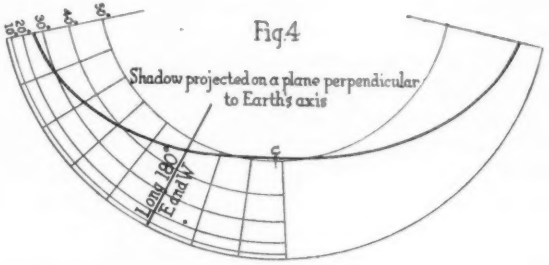


Figure 3 is a projection of a portion of the northern hemisphere on a plane which is perpendecular to the earth's axis. It includes the two parts of the surface upon which the shadow falls, and the angle (α) through which the earth rotates in 3 hours and 10.7 minutes. The angle $\frac{\alpha}{2}$ measured on the parallel cc' gives c' in Figures 3 and 2. The point d (Fig. 2) bisects $a\,c$; and the angle $\frac{\alpha}{4}$ measured on the par-

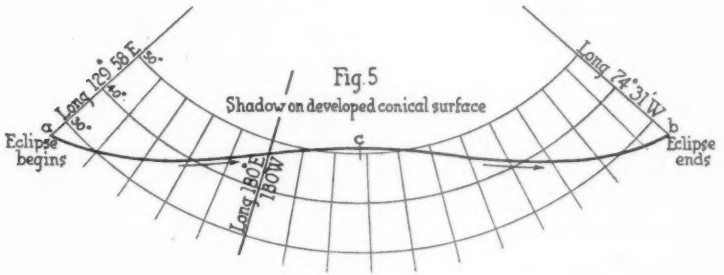
allel through d, gives d' in both figures. Similarly the point g bisects $a\ d$; and the angle $\frac{a}{8}$, measured on the parallel through g, gives g'. In the same way any number of points may be found. The curves $a\ g'$ $d'\ c'$ (Figs. 2 and 3) are projections of the first part of the shadow which begins at a, and as the earth rotates the points g', d' and c' respectively take the positions g, d and c.

The figures illustrate the comparative velocities of the moon and of the earth's surface at the parallels of latitude over which the shadow passes. For example $a\ c\ :\ c\ c'$ represents the moon's velocity as compared with that of the earth's surface at latitude 50° 51′.



The two parts are united in Figure 4 which shows the continuous shadow between longitudes 129° 58′ E and 74° 31′ W.

Figure 5 represents the developed surface of a cone which intersects the zone on which the shadow falls in two parallels which are equidist-



ant from the most northerly and southerly and middle parallels. The form of the shadow in this development is determined from Figure 4.

Trinity College, Hartford, Conn.

November 7, 1917.

CANOPUS AS SEEN FROM FLORIDA.

JENNIE LYNNE KYLE.

The monthly articles on "The Heavens" in the Scientific American by Professor Henry Norris Russell, Ph. D., of the Princeton University Observatory, are exceedingly interesting and instructive, and I anxiously await the appearance of each one. A full description of the constellations visible in the northern latitudes is given, but we who live below the thirty-first parallel of north latitude regret very much that our beautiful southern constellations must be omitted in this review. We need a map of the constellations of the Southern hemisphere in POPULAR ASTRONOMY, just as the map of the constellations of the Northern hemisphere is given.

Atmospheric conditions in Florida are exceptionally good for observing the wonders in the sky in that nearly all nights are unusually clear. The heavy rains which occur in the afternoons cleanse the atmosphere of all dust particles, and with no smoke or fog, even at sea level, Florida offers unusual advantages to those interested in Astronomy.

Here our constellations appear sharper in outline—our stars in their reds, blues and yellows, shine brighter—the diffused appearance of the nebulae and star clusters are clearer to the eye—the meteors appear larger and display more brilliant trains as they glide through our atmosphere on the last stage of their journey through space. And the comets!—their soft, tenuous appendages of veil-like matter give a greater depth of tone set on a background of our clear and cloudless skies. At perigee when our moon is nearest to us, the flood of light she affords seems greater than anywhere on this planet. Our soft, balmy air calls one to the outdoors in the evenings, and immediately one is attracted by the brilliant display of these wonderfully beautiful and grand things in nature. Land and water and clear skies make nights in Florida ideal for astronomical study.

That part of Florida lying below the 28th parallel of north latitude is especially good for views of the South Polar constellations. All the constellations from the North Pole as far south and including Argo Navis, Centaurus, Crux and Eridanus can be seen from here, which means that all the twenty first magnitude stars are visible from south Florida.

The four wonderful constellations—Argo Navis, Centaurus, Crux and Eridanus, which surround the South Pole, contain five of the first magnitude stars. These five first magnitude stars are Canopus in Argo Navis, Alpha and Beta Centauri, Alpha Crucis and Achernar in Eridanus.

Canopus may be seen as far north as the thirty-first parallel of latitude. Alpha and Beta Centauri and Achernar are not visible above the twenty-ninth parallel of latitude. Beta, Gamma and Delta Crucis are seen as far north as St. Petersburg, Fla., but Alpha Crucis is visible only 27 degrees north latitude. Each of these five great suns possesses an individual charm and distinction.

Alpha and Beta Centauri, with Crux—the Southern Cross—are used by mariners and landsmen in the Southern Hemisphere, as Ursa Major and Polaris are in the Northern Hemisphere, and their brilliant beams have guided many a ship to shores of safety.

Alpha Centauri, of all stars in the Universe, is nearest to us, with a parallax of 0″.75, or 4.3 light years away. Among the twenty first magnitude stars Alpha Centauri ranks third in brightness. Its colors of yellow and deep yellow fill one with admiration while viewing it through a telescope of large aperture.

Alpha Centauri is the finest binary in the whole heavens. The period of this beautiful pair is 81 years.

And Alpha Crucis—the brightest gem of the Southern Cross and the second finest double star in the heavens! It lies at a distance of 59 light years away, with a brilliancy 207 times that of our sun, yet throughout all the ages it seems to have remained in a state of absolute fixity. It is composed of two stars—both very brilliant—of 1.6 and 2.1 magnitude, and a third companion of the sixth magnitude. Out on the waters of the Gulf of Mexico I have watched the Southern Cross rise out of the water, and as it crossed the meridian stand almost perpendicular to the horizon—then describe its narrow circle and disappear. Stars near the South Pole are seen for a short while only each night, as the visible arcs of their circles are short.

Achernar lies in a latitude a little below Canopus—64 light years away—shining with a brilliancy 350 times that of our sun. In middle Florida Achernar lies low on the horizon—alone in its richness and brilliancy, about equally distant between Canopus and Fomalhaut.

But it is not Alpha and Beta Centauri, and Achernar, and Alpha Crucis of the Southern Cross that hold and fascinate the eye and soul of the southern observer. It is the brilliant Canopus in Argo Navis—the great and wonderful Sun Canopus—one of the most splendid objects in the sky. Canopus—distant 466 light years—55,000 times

more brilliant than our sun and so hot that, should our whole solar system approach within a million miles of his awful mass of burning gases, it would immediately vaporize.

The constellation Argo Navis covers more degrees of space than any other constellation and I do not think there is any gathering of stars more interesting. It contains 827 naked eye stars and the entire constellation is visible from Key West.

That part of the constellation containing Canopus is visible as far north as Jacksonville, Fla., where Canopus reaches an altitude of about ten degrees. In November and December we see him between midnight and dawn, and in January and February he is well up at dusk, but disappears about nine o'clock. During March the visible arc of his circle becomes less and less, and he sets not later than eight o'clock.

But it is during these evenings that he seems biggest and brightest. At this time of the year the night air is always still. Here, space seems transparent, and Canopus blazes, flashes and coruscates until he seems to magnetize the heavens. No other star in the sky possesses such fascinating power. Sirius is ranked as the brightest star among the visible suns, yet here Canopus appears much larger and brighter. The light from Sirius is more quiet and serene—planet-like—but Canopus is never still. Spasmodically he gushes forth in fury, then heaves and sighs, and again gleams forth as if in a great rage. One stands overwhelmed with wonder and admiration while gazing on a thing so magnificent.

Because of his nearness to the horizon here, his color is a rich golden-yellow-red all combined. I stand and watch his movements each evening, loath to let him sink below the horizon so early.

By May 10 he is lost to view here and passes on in his apparent journey around the South Pole—yet only to continue on his true journey in space, receding from us at the rate of 12.4 miles per second.

Before we behold his sparkling form again in November, he will have traveled nearly two hundred million miles farther from us, yet so vast is his distance from us that he will shine in as great splendor as in May.

Silent admiration is our deepest and most appreciative expression of adoration for Canopus, the grandest of all suns in the universe.

Jacksonville, Fla.

THE TOTAL SOLAR ECLIPSE OF 1918 JUNE 8: A RECONNAISSANCE.

EDWIN B. FROST.

For investigating a site or sites for observing the total solar eclipse of June 8, 1918, President Judson of the University of Chicago authorized Professor Barnard and the writer to make a trip to Colorado and vicinity in September, 1917. We were away from the Observatory for a little over two weeks for this purpose and inspected three sites which we had selected in advance for special reasons, namely, Denver, Colorado; Green River, Wyoming; and Matheson, Colorado. It has been suggested by the Editor of POPULAR ASTRONOMY that the results of our study of the matter might be of value to others who are planning to observe the eclipse and therefore these informal notes are written.

It is not easy to select a station for observing a total solar eclipse from an examination of the ordinary meteorological records or from the special estimates of cloudiness of the sky which may have been made for this purpose by voluntary observers at the proper time of year and of the day.

I. The data available to us were contained in the annual volumes entitled "Climatological Data for the United States by Sections," of which Volume I was published in 1914. These give the reports of the voluntary and official observers in the different sections for each month.

In this form we had the data for June 1914-17, as well as the annual volumes for 1915 and 1916.

II. The pamphlet on the "Total solar eclipse of the sun, June 8, 1918," published by the Nautical Almanac Office as a supplement to the American Ephemeris for 1918 *, gives data for a few stations each in the States of Washington, Oregon, Idaho, Wyoming, Colorado, Kansas and Oklahoma. They include average weather conditions in June as to temperature, precipitation, percentage of clear days, percentage of rainy days, and the percentage of sunshine during the first fifteen days of June at eight Weather Bureau stations. For the same stations other tables give the prevailing hourly wind direction during the first fifteen days of June at different hours of the day, and the average wind velocity in miles per hour.

* Sold by the Superintendent of Documents, Government Printing Office, Washington, D. C., for 30 cents a copy.

III. We were also given opportunity, through the kindness of Professor D. P. Todd, to examine the records which had been kept on blanks furnished by him to voluntary observers, along the track of the eclipse, of the cloudiness of the sky during June for the years 1912-17.

IV. Moreover, we also had the benefit of the advice of Professor F. H. Loud, of Colorado Springs, who has had long experience of the weather conditions in Colorado. He collated for us the averages from the records of numerous stations in Colorado.

V. A new map of the rainfall of the United States has recently been published by the Weather Bureau, which shows clearly the regions of low annual precipitation. While this applies to the whole year, it nevertheless gives data from which inferences of value may be derived.

Careful study of all these data was made, but the impression could not be avoided that, after all, a good deal has to be left to chance. Stations which may have a very good record for several years will have bad ones in a particular year.

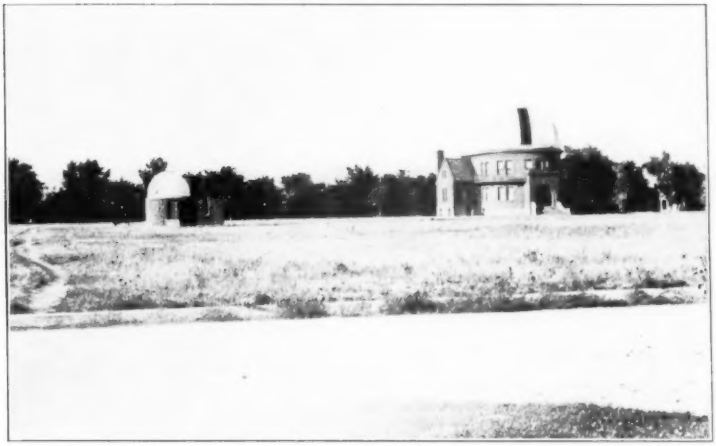
On the basis of the data collected by Professor Todd, the statistical evidence would seem to favor Goldendale, in the state of Washington, and Coldwater, in the state of Kansas; but the first-named station is too far west for an expedition from this observatory; while in Kansas the sun would be too low and the duration shorter than for stations farther west.

It is also necessary to take into the reckoning the personal equation in meteorological observations. Thus from the data in the eclipse pamphlet of the Nautical Almanac, Steamboat Springs, Colorado, which is at an altitude of 6700 feet, would seem to have a great advantage over all other stations concerned in respect to percentage of clear days (with the exception of two stations in Oklahoma). Thus, Steamboat Springs is given a percentage of 70 for clear days, as against 40 for Denver, 50 at Pocatello, Idaho, 33 at Baker, Oregon, and 27 at Seattle. Holdenville, Okla., records 80 per cent of clear days in June, with 20 per cent of rainy days, which leaves nothing for cloudy days without rain, or for partly cloudy days. We have expert meteorological opinion that too much reliance should not be placed upon such figures.

Other considerations, in respect to afternoon cloudiness, etc., quite changed the favorable opinion we had first received as to Steamboat Springs, so that finally we did not visit the place at all. In general, we were advised to avoid all such stations surrounded by high mountains, on account of the well known probability of the development of clouds in the afternoon.

The tendency toward clouds in the afternoon is well shown in Table II of the pamphlet from the Nautical Almanac office. Thus, during the first fifteen days of June, Baker, Oregon, has 86 per cent of sunshine

PLATE IV



THE CHAMBERLIN OBSERVATORY OF THE UNIVERSITY OF DENVER, WITH STUDENTS' OBSERVATORY AT THE LEFT

THE SMALL BUTTES AT GREEN RIVER, WYOMING

The proposed site of the station of the Yerkes Observatory is in the foreground of the picture

between 11 and 12 noon, which falls to 51 per cent between 4 and 5 p. m. At Pocatello, Idaho, 86 per cent between 11 and 12, decreases to 54 per cent between 4 and 5; at Denver, 84 per cent between 10 and 11, is reduced to 49 per cent between 4 and 5. No such marked falling off is found at the stations in Kansas or Oklahoma, which are away from the mountains.

It will be remembered that at the coming eclipse the period of totality will be as follows at some of the different points.

Southbend, Washington	122 sec.	Denver, Colorado	89 sec.
Baker City, Oregon	118	Hartland, Kansas	83
Pocatello, Idaho	104	At point where track enters Florida	59
Green River, Wyoming	98		

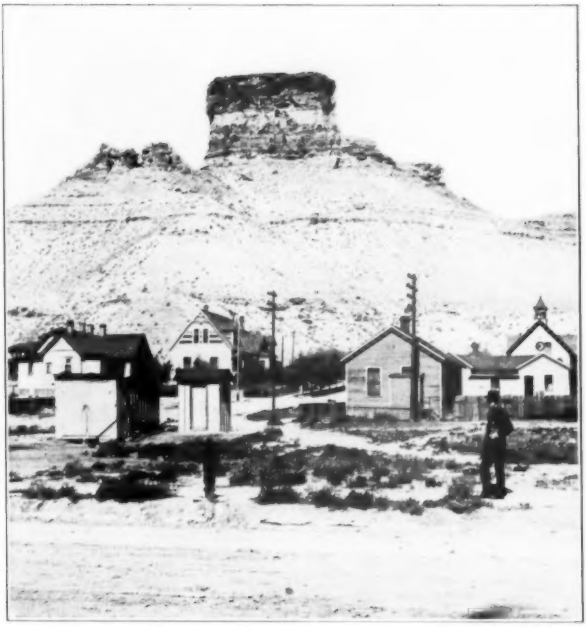
Director Howe, of the Chamberlin Observatory of the University of Denver, had most courteously offered us the hospitality of that institution for the eclipse and had placed at our disposal the fine 20-inch Clark equatorial. This offer was accepted and accordingly Denver was the first point to be visited. It is unusual for an astronomical observatory to be near the central line of a total solar eclipse and it is of course of the utmost advantage to have at hand the facilities of a fixed astronomical station, such as the accurate time, chronographs, and telescopes on fixed mountings. It was important for us to know whether the chance of freedom from clouds in the afternoon was great enough to justify us in making this our principal station for the expedition from the Yerkes Observatory. We found the situation an excellent one, as we had expected, with great freedom from smoke or jar of traffic, as the observatory is situated about four miles northeast of the center of the city. There is a large open space around the observatory which can be utilized for setting up various instruments, and the grounds are not so much developed in the way of landscape architecture that injury would be caused by laying out a coelostat or the erection of piers. We received every courtesy from the Chancellor and officers of the University, as well as from Professor Howe, and proceeded first to test the quality of the 20-inch telescope as a photographic instrument. This objective is of the type so designed that by reversing the front lens (of crown glass) it becomes available for photographic work with the use of the blue and violet rays. The telescope had never been used in this way, although it had been provided by Saegmuller, its constructor, with facilities for such use, the focal length being then about 36 inches shorter than when used for visual purposes. Several days were required to make the necessary changes at the eye-end. We began this work on Monday, September 10, but after the

instrument was ready for the first trials by photography we were prevented by cloudiness on several nights from making the necessary exposures.

As the weather did not give prospect of improvement immediately we left on the evening of September 15 for Green River, Wyoming, where we spent the next day, returning to Denver on the afternoon of the 17th. We were then able to make the experiments for finding the photographic focus, but were disappointed to discover that the plate-holder could not be pushed far enough in to reach the true photographic focus. This involved additional mechanical work, but finally it was possible to locate the focus on a 4x5-inch plate which was put in a provisional plate-holder several inches inside of the one provided by the constructor of the telescope. Then, with his usual skill in such work, Professor Barnard finally secured excellent photographs of the nebula in Orion and of the Pleiades, which demonstrated to us the excellent definition of the telescope when thus used photographically. A moving plate-holder had been provided by Saegmuller, carrying an eye-piece which was intended to be at the focus of an auxiliary lens of 5 inches aperture, mounted near the 20-inch objective. This could not be used, however, without more extensive alterations, and the guiding was accomplished with great difficulty, in part due to the fact that the slow motions had to be disarranged in making the alterations at the eye-end. We were satisfied, however, with the result of our somewhat laborious experiments that this telescope could give good photographic images, and it is our belief that the Denver equatorial would be very well adapted for use for the determination of stellar parallaxes by photography, particularly as the atmospheric conditions at Denver are more favorable in respect to clearness than steadiness of images. We are greatly indebted to Professor Howe for the assistance he was able to give us, despite the fact that the beginning of the term at the University called for all of his time during the day in the discharge of his duties as Dean.

It is not at all fair to judge a station by observations covering a few days in any one year; and still less at a different season of the year from that of the eclipse which is to come. During the ten afternoons that we were in Denver or vicinity, we watched the sun carefully at the time of the eclipse, namely 4:22 p. m. There were only two afternoons which would have been entirely satisfactory for the observations and two others on which fairly successful observations probably could have been made. The tendency for clouds to appear in the west in the afternoon was evident; but this might not be true in June, or in some other year in September. While we were there the drought of the summer was first broken and thunder showers occurred several times.

PLATE V



"CASTLE ROCK" 700 FEET ABOVE GREEN RIVER, WYOMING

The top can be reached by a ladder. What a place from which to view the onrushing shadow at the eclipse!

The photographs in Plates IV, V and VI were taken by Professor E. E. Barnard

From our study of the data available, referred to above, we had concluded that the conditions at Green River were as promising as at any station east of Idado. It is situated in the so-called Red Desert, traversed by the Union Pacific Railway, an area in which the annual rainfall is about 10 inches. The elevation is high, being 6077 feet at the railway station of Green River. A good meteorological record has been kept at Green River for 13 years at the Court House by William Hutton, volunteer observer. The normal annual precipitation is 6.5 inches and the normal precipitation in June is 0.37 inch. At this station, in 1915, June was exceptionally rainy, 0.88 inch with six clear days, twenty-one partly cloudy and three wholly cloudy; 0.01 inch of rain having fallen on seven days. In 1916 June was exceptionally dry, with rainfall of 0.04 inch, and with nineteen days clear, eleven partly cloudy and none wholly cloudy, rain falling on only one day in the month. The region is liable to pretty strong winds, but it did not appear that dust storms were to be feared. A large butte, called "Castle Rock" (the customary name for such buttes in the West) rises about 700 feet above the village toward the east. Many picturesque smaller buttes are found partially buried in sand toward the northwest from Castle Rock, and there are some palisades along the river. It was from this point that Major Powell started on his famous voyage down to the Grand Canon of the Colorado in 1869.

Green River has recently been made Division Headquarters of the Union Pacific and the trains of the Oregon Short Line are made up here, although they do not leave the tracks of the main line until the station of Granger is reached, 30 miles farther west. The population is about 1300 and has grown so rapidly on account of the railroad business that it is difficult to secure accomodations. It this respect conditions would be more favorable at the next station, fifteen miles east, Rock Springs, which has a population of nearly 6000. Rock Springs is about eight miles north of the central line, but this would shorten the duration of totality only slightly. There are very important mines of high-grade bituminous coal at Rock Springs, from which a million tons have been obtained annually.

The day which we spent at Green River, September 16, was one of extraordinary clearness. The transparency had not been often equalled in the experience of either of us. It seemed very easy to select a site a few hundred yards beyond the northern limit of the village, in the area of sand and small stones near some of the smaller buttes. The horizon was entirely free to the northwest and the danger from smoke from either the locomotives or from the railroad shops seemed to be very small. The site was entirely protected from winds from the north and east by the high ridge leading to Castle Rock.

We did not have a telescope with which we could test the steadiness of the seeing, but with the sun at an altitude of 37° at the time of totality and in an azimuth almost due west across the rather wide valley of Green River, we do not anticipate difficulty from this cause. The daily range of temperature in such a situation is very considerable, as would be expected: the days are warm and the nights cold, if clear. Adjustments of apparatus at night with mirrors would therefore have to be made with allowance for this. Under all the circumstances it seemed to us that Green River would be the most satisfactory place for our principal station. We cannot recommend that any large number of other parties should select this station because of the difficulty of securing accomodations in the village.

We left Denver on September 19 and proceeded to Colorado Springs, where we enjoyed the hospitality of Professor Loud, to whom we were also indebted for much preliminary data regarding stations in Colorada. The transparency of the sky was also very fine here. On the next morning, Mr. E. P. Shove, a Trustee of Colorado College, most courteously placed at our disposal his fine Packard and chauffeur and with a party consisting of Professors Loud, Cajori, Albright and Tileston, we had a delightful trip to the northeast over good roads paralleling the line of the Rock Island Railway. We stopped at the village of Simla and then passed on to a point near the central line which had already been "spied out" by Professor Loud a few days in advance of our arrival, on learning that we wished to inspect this vicinity. This is four miles from Simla and about 60 miles from Colorado Springs, on high land (6000 feet) slightly rolling. The village of Matheson lies about a mile and a half farther on.

There are a few trees, but the country was well covered with grass even in September and there could be little danger from dust in June. There is nothing to prevent the wind from blowing if it wishes to, in this part of the world, but we did not receive any cautions in this respect from any of the natives. Water can be easily obtained from a well near at hand, and living accomodations could be obtained at Simla or Matheson. Matheson Brothers, whose ranch nearby, seen in the distance in the picture, kindly offered to any visiting scientist free use of the land, which did not appear to be cultivated. The site is far from the mountains and about equally distant from Denver and Colorado Springs. The nearest important railway station is Limon, Colorado, about twenty miles to the northeast, where the Union Pacific's line between Denver and Kansas City crosses the Rock Island.

We regard this a very promising situation. The weather has been recorded for many years by two volunteer observers in this vicinity: Mr. W. Hamp, whose ranch is twelve miles east and about eleven miles

PLATE VI

LOOKING NORTH FROM SIMLA, COLORADO
Tracks of Rock Island Ry. in foreground

NORTHERN VIEW FROM SUGGESTED ECLIPSE STATION SITE BETWEEN SIMLA AND MATHESON, COLORADO. ELEVATION 6,000 FEET
Freight train of Rock Island Ry. at right hand edge of picture

south of Matheson; and Mr. F. L. Palmer, who lives about eleven miles east and one mile north of Matheson. The normal rainfall in June at Hamp's is 1.80 inches, with the number of days on which rain falls three or four. We have expert meteorological advice that a clearer sky may be expected in this part of Colorado than at points farther west in the track of the eclipse.

It is our suggestion that this site near Matheson be called the "Colorado College Station." The College is not itself able to install any large equipment, but has some valuable apparatus and would very gladly coöperate with other parties who may bring apparatus from institutions farther east. We are advised that the station is already under consideration by one or more parties who plan to observe the eclipse. The saving in the expense for freight shipment and for passenger fares is very considerable for eastern observers over points west of Colorado. The high elevation and longer duration of totality offer an advantage over some of the points in western Kansas, which also are very promising in respect to weather.

At this writing, the necessary appropriations for observing the eclipse by the party from the Yerkes Observatory had not been authorized by the Trustees of the University of Chicago, but it is learned that action has since been taken. It may be of interest to add a few words as to some of the different observations which are planned by our party.

Professor Barnard will devote his attention to photographs of the corona. It was hoped that we could obtain in time a 12-inch lens of 60-feet focus, but the war conditions have finally made it necessary to abandon this hope, and the 6-inch lens used with our coelostat at Wadesboro, N. C., in 1900, will again be employed. We also hope to take the 12-inch "Kenwood" telescope of the observatory and mount it on a temporary pier. Using the photographic objective belonging to this instrument, Professor Barnard will also obtain photographs of the corona.

Professor Parkhurst proposes to measure photometrically the total light of the corona and to investigate its distribution both visually and photographically, using among other pieces of apparatus the Zeiss camera (145 mm aperture, 81 cm focus) of U.-V. glass and the six-inch reflector, each provided with objective prisms of the U.-V. glass.

Professor Barrett will attempt to photograph the infra-red flash-spectrum with a small concave grating used by the writer in 1900, on plates dyed with dicyanin, according to the very successful method used by Mr. W. F. Meggers of the Bureau of Standards in obtaining his fine photographs of the infra-red solar spectrum illustrated in the *Astrophysical Journal* for January (Vol. 47, p. 1, 1918). We propose

to carry an additional mirror on the coelostat, as we did in Wadesboro, from which other photographs of the coronal spectrum may be obtained. It is also our intention to use our sky patrol and its apochromatic and Tessar lenses, the one with an objective, prism.

It is the present plan to adapt one of our spectroscopes to the 20-inch equatorial at Denver for photographing the spectrum of the corona with a view to determining, if possible, it's rotation.

In the opinion of the writer no more important work could be done than to investigate the emission of coronium around the sun by the interferometric method of Fabry and Buisson, so successfully applied by them and M. Bourget of Marseille in photographing the Orion nebula, and thus determining the wave-lengths at many points of the nebula, from which the different velocities at various points in the nebula were determined (*Astrophysical Journal*, Vol. 40, pp. 241-258, 1914). The visit of M. Fabry to the Observatory during the past summer, when he was chairman of the French Scientific Mission to the United States Government, gave an opportunity for presenting this suggestion to him. He concurred in the writer's view of the importance, but we recognize that there are some considerable difficulties in the execution of such observations. A serious difficulty is the impossibility of testing and adjusting the apparatus by emission lines of coronium, because the few seconds of totality would of course be too brief for any attempts at adjustment. There is also the question as to whether a sufficient length of exposure could be obtained for securing a photographic record of the interference rings. A further obstacle to the realization of this plan is the great difficulty of having any optical work done during war times by our professional opticians. Perhaps some physicists who have apparatus suitable for attempting this experiment may wish to associate themselves with some party having the telescopes necessary for the purpose.

The consideration in these strenuous war times of such unworldly matters as the scientific utilization of a total solar eclipse may seem to some readers almost as lacking in patriotism. Many of our younger physicists and astronomers will doubtless be prevented from making observations by their preoccupation in work for the Government or in teaching navigation for the Shipping Board; but for those who are otherwise at liberty for scientific work, no apology is necessary for their great desire to participate in observing such an interesting and relatively rare phenomenon of nature, which fortunately passes over so large a part of our own country.

Yerkes Observatory
January 16, 1918.

CLOUD CONDITIONS ALONG THE PATH OF TOTALITY, 1918, JUNE 8, AS DETERMINED BY LOCAL OBSERVATIONS, 1912-1917.

DAVID TODD.

Suitable blanks were prepared and sent out each year, 1912-17, to about fifty voluntary observers at places along this path. The results have been tabulated by Professor R. W. Porter, of the Massachusetts Institute of Technology, and the paper will subsequently be presented in full. To assist observers in an early decision as to the general location of their stations, those showing the best chances of clear skies are given in the following table:—

TABLE OF STATIONS NEAR THE MIDDLE OF TOTALITY-PATH SHOWING BEST RECORD FOR GENERAL CLOUDINESS.

Station	Lat.	Long.	No. of Years Covered*	Percent of Cloudiness General State of Sky	Sky near the Sun
	°	° ′			
Goldendale, Wash.	+45.8	120 45 W	5	32	19
Arlington, Ore.	45.7	120 15	4	19	11
Lexington, Ore.	45.5	119 40	3	28	18
Cambridge, Idaho	44.5	116 40	3	28	17
Cheyenne Wells, Col.	38.8	102 20	3	29	36
Coldwater, Kan.	37.3	99 20	5	26	17
Alva, Okla.	+36.8	98 40 W	5	29	17

For the convenience of anyone who may desire to consult the original records at all these stations, from Washington to Florida, I have arranged to send the complete data to Professor Frost at the Yerkes Observatory, where they will be accessible for this purpose.

Cocoanut Grove, Fla.
January 3, 1918.

* Excepting 1914.

IS THE SUN DUE TO EXPLODE?

BENJAMIN O. BAXTER.

We are told that our sun is of advanced age, as ages are reckoned among suns.

Like all other things in creation, suns are brought into existence, and pass away, or pass out of the class of celestial objects known as suns, or stars.

Man has learned to distinguish age among stars by the color of their light. A white star is a young star; perhaps only a few hundred millions of years of age since it gathered from clouds of hot gases into globular form and started out as an independent sun. Yellowish light denotes middle age, and red or crimson indicates mature age; which, as viewed by humanity, would look like several short eternities.

We are also told that all stars, which are merely distant suns, are shrinking in size as they cool off and contract, and the theory was advanced by George Henry Lepper, that while the volume of the star diminishes through contraction, the heat of the core increases with the pressure brought to bear on it and that when this pressure reaches the limit the pent up materials explode, and the star, or sun, is reduced to a cloud, or puff of fog, called nebula.

When we consider the extent to which suns contract we are able to form some idea of how much the core is squeezed. Earth is about 93,000,000 miles from the sun. There may have been a time when the sun was large enough to fill up all the room clear out to where we are, or farther. If so, it has contracted 93,000,000 miles from each side, which would give the hot center twice 93,000,000, or 186,000,000 miles less of room; so if we have any suspicion that the center of the sun contains any of the ingredients of which dynamite is made we might allow ourselves to get into "hot water" wondering how long it can stand the pressure, considering that our sun is already growing old and perhaps subject to a decline of his powers of resistance.

Is our sun in danger of blowing up? We may reason not, because we have never seen one explode. On the other hand we must remember that suns are not made in a hurry, and that they take their own time about what they do, and that while man's knowledge of suns covers

only a few thousand years, their ages could not be expressed in any manner intelligible to the human mind. Still we must draw the line somewhere, and although our sun may have weathered the celestial storms of an eternity, that very fact may prove that the time for some variation may soon arrive. Our sun is said to be a variable star and variables of a certain class are those stars which are due to explode!

When our sun explodes, what else will happen?

If a little ripple among the superficial layers of the sun, known as a sun-spot, 93,000,000 miles away, upsets the operation of electrical utilities on earth, how much of a jolt will we get when the whole sun is instantaneously resolved to a cloud of gas composed of stone, iron, and other substances even heavier and harder, but so hot that they are reduced to vapor, and so elastic that from their sudden release they expand to the limits of the solar system, a region 556 billions of miles in diameter.

In such a maelstrom I apprehend that earth and the other planets and satellites would each flash once like the fire-fly, and be lost in nebula. Will astronomers kindly enlighten us?

Chicago, Ill.
1546 E. Sixty-fifth St.

SUGGESTIONS CONCERNING THE PLACE OF THE ZODIACAL LIGHT IN THE SOLAR SYSTEM.

REV. W. E. GLANVILLE, PH. D.

I. There are two chief theories concerning the place of the Zodiacal Light in the solar system: (1) That it is sunlight reflected from meteoric matter circulating about the Sun, within Mercury's orbit and extending, say 1,000,000 miles, beyond the orbit of the earth. (2) That it is an earth ring. Supporters of theory (1) contend that the enlarged appearance of the light at the equinoxes indicates that the material from which the light is reflected stretches away towards the sun with increasing thickness and density. Bearing in mind the fact that the markedly enlarged appearance of the horizon lights at the equinoxes is a phenomenon peculiar to observations made in temperate latitudes and relatively negligible for observers in the tropics, I suggest that the enlarged appearance is due for the most part to the high angle with the horizon made by the ecliptic at the equinoxes—for the most part, I repeat, because it is a well-known fact that constellations always appear more spread out in the neighborhood of the horizon than in the zenith, from whatever cause. Hence, the enlarged appearance of the

zodiacal light near the horizon is not necessarily fatal to the earth ring theory but may be most agreeable to it. Further, the gradations of brightness along the horizon between the equinoxes (spring to autumn and autumn to spring) are, on this interpretation, attributable to the periodically varying angles made by the ecliptic with the observer's horizon in temperate latitudes.

Let us assume the earth ring theory for the nonce:

Figures 1 and 2 represent the night side of the earth (shaded portion) in the evening at the vernal and the autumnal equinox respectively; the observer's station in a N. temperate latitude is represented by x; the broken line represents the equator; the unbroken line the ecliptic plane corresponding to the zodiacal light curve. It is surely clear from Figure 1 that the observer at x has a view of the Zodiacal Light much more intensified in brightness than the same observer at x in Figure 2, six months later. Figure 1 represents the equator-ecliptic

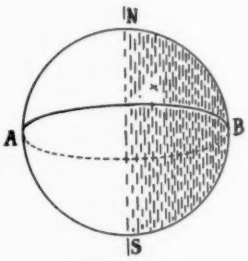


FIGURE 1.

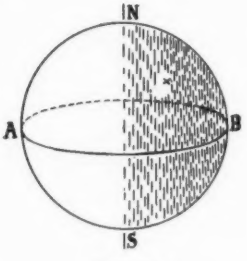


FIGURE 2.

configuration at the vernal equinox; Figure 2, the same configuration at the autumnal equinox. Therefore from the vernal to the autumnal equinox and from the autumnal to the vernal equinox the angle between the observer's horizon at x and the zodiacal-light will be constantly

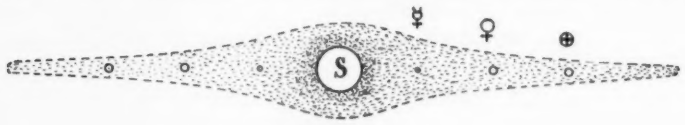


FIGURE 3.

decreasing in the first case and constantly increasing in the second case, thus accounting for the decreasing and increasing gradations in brightness as observed during the evening hours. So, I submit that the intensified brightness of the horizon lights at the equinoxes is not incompatible with the Earth ring theory.

II. Advocates of theory (1), e.g. Professor Newcomb, picture the Zodiacal Light material as arranged according to Figure 3.

According to this diagram it is estimated that the Zodiacal Light material extends beyond the earth for a considerable distance to a vanishing point. Assuming this to be the real state of affairs the question arises: Why is not the illumination seen more brightly in the eastern sky in the evening?

While Figure 4 is not drawn to scale it is sufficient to show that the Earth's shadow is a slight affair compared with the extent of the Zodiacal Light material all through it and surrounding it. After making

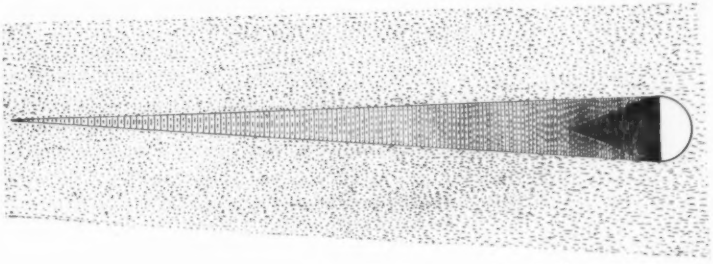


FIGURE 4.

allowance for the oblique appearance of the plane of the ecliptic in the east, say at and near the time of the vernal equinox, it is still hard to see why the light does not show up more conspicuously than it does in that quarter of the sky during the evening hours. Reports of observations both in the tropics and in temperate latitudes are unanimous in their record that during the early evening hours at any time of the year the light is extremely faint towards the eastern horizon even under the best conditions. Such testimony is not repugnant to the earth ring theory but quite agreeable to it.

III. In support of theory (1) it has been urged that the Zodiacal Light is visible along the northern horizon during midsummer nights. Observers at Lick Observatory, notably Dr. E. A. Fath, have decided that the luminosity in question can be none other than the Zodiacal Light surrrounding the solar north pole. Other observers are by no means satisfied that such is the case. It is well known that there is twilight all night about midsummer at any place whose latitude is not less than 48°. The question of the height of the atmosphere is one still under debate. Assuming that it extends from 200 to 250 miles above the earth's surface it is agreeable that the luminosity ascribed by the Lick Observatory astronomers to the Zodiacal Light may in fact be a twilight zone.

IV. The earth's sphere of activity is admissible in a discussion of the Zodiacal Light problem. By the sphere of activity is meant the

radius within which the Earth's gravitational force would hold a body subject to itself (as e. g. the Moon) and it extends to a distance of about 480,000 miles. That is to say, any meteoric matter within that radius would take up orbits about the earth—would form an earth ring.

V. The plane in which such meteoric matter would revolve presents a question of no little complexity to the mathematical astronomer. Reports of careful observers of the Zodiacal Light are not in agreement. Some declare that it lies exactly in the plane of the ecliptic; some, that it is inclined to the plane of the ecliptic at varying degrees, estimated by different observers as from 3° to 5°. The problem may be stated thus: In what plane would meteoric matter situated between the Earth and the Moon circulate about the Earth, regard being had to the gravitational influence of the Sun, the Moon and the Earth?

VI. The claim has been advanced that the Zodiacal Light is an extension of the solar corona. It may be sufficient to point out that the Zodiacal Light does not show any connection whatever with coronal vicissitudes. On this point, I think, all special observers of the Zodiacal Light are agreed.

VII. As recently as last evening, November 4, at 7:15 I had no difficulty in tracing the Zodiacal Light band extending from Venus in the west to Jupiter in the east. Were this light visible only 80° or 90° elongation from the sun the earth ring theory could not possibly be maintained. But that it appears as a belt arching the sky in the evening more or less faintly according to the season may be admitted as evidence in favor of its being an earth ring.

VIII. As to the Gegenschein my conclusion is that it is sunlight focussed, reflected from meteoric matter composing the Zodiacal Light band situated 180° elongation from the sun. It is known that for about 100,000 miles from the earth's surface the umbra of the earth's shadow is absolutely dark. Beyond that limit light refracted from the earth's perimeter would be reflected from any object in the earth's shadow, very faintly at first, more distinctly as the distance from the observer increases, according to Fresnel's law. This, it seems to me, gives a quite satisfactory explanation of the Gegenschein phenomenon.

Finally, I desire to add that I am perfectly open-minded concerning this problem, but after more than three years' continuous observation of the phenomenon I feel strongly of the opinion that the earth ring theory fits the facts.

NOTE: From a letter received from an astronomical friend in England since this article was submitted to the Editor I extract the following quotation: "We seem forced to fall back on a modification of the Moulton hypothesis and to see in the Zodiacal Light and its different features the effect of the presence of an immense number of minute

bodies revolving round the earth in orbits profoundly modified by the attractions of the Sun and the Moon.....The planetesimal ring, I think, is very elliptical, the major axis being nearly along the line joining the Earth and the Sun, the Earth lying nearer the end of the axis nearest the Sun."

St. Peter's Rectory,
Solomons, Md.
1917, November 5.

THE PRINCIPLE OF CONSERVATION OF MOMENT OF MOMENTUM.

F. R. MOULTON.

Although Newton's laws of motion and their immediate consequences have been known for more than 200 years, yet there is occasional confusion regarding them. The terms force, momentum, and energy are sometimes used interchangeably in spite of the fact that they are as distinct as mass and velocity. But there is greatest confusion and error regarding the moment of momentum of a body. For example, in the October number of this magazine Mr. N. Johannsen denies the validity of the principle of the conservation of moment of momentum in a system free from external forces. After making a number of remarks in which he confuses force and moment of momentum, he suggests an experiment which he asserts would prove, if tried, the falsity of the principle in question, and then goes on to make such statements as: "At present the sun's moment of momentum is not one twentieth that of Jupiter, though originally it was a thousand times greater." The discussion and statements of Mr. Johannsen are so utterly misleading and erroneous that it appears worth while simply to restate the principles, although they have been well known for more than two hundred years, and are clearly set forth in a dozen books on mechanics in any astronomical and mathematical library.

Consider first the case of translation, because it is simpler than that of rotation and presents many analogies. Suppose the system is composed of n masses $m_1, \cdots, m_n$, whose velocities parallel to the x-axis are $x_1', \cdots, x_n'$. The x-component of momentum along the x-axis is

$$m = m_1 x_1' + \ldots + m_n x_n' = \sum_{i=1}^{n} m_i x_i'.$$

If the system is a continuous mass, such as a sun or a nebula, the sum is replaced by the integral

$$m = \int x' dm,$$

where the integral extends over the whole mass. There are similar expressions for the other components of momentum.

Two things are true about the momentum. (a) If the system is subject to no external force, the components of momentum are constant. This is true if the system is composed of isolated masses which do not collide, such as the sun and planets; it is true if the isolated masses collide, for what one loses in momentum the other gains; and it is true for a continuous mass, whatever internal currents there may be. (b) If the system is subject to an external component of force in any direction, for example the x-direction, there is a change of momentum in that direction. The rate of change of momentum is directly proportional to the external force. This is true whether or not there are internal collisions, or currents in case of a continuous mass.

A moving system also has energy of translation. Suppose for simplicity that there is motion only in the x-direction. Then the energy of translation, or kinetic energy, is

$$e = \frac{1}{2}[m_1 x_1'^2 + \ldots + m_n x_n'^2] = \frac{1}{2}\sum_{i=1}^{n} m_i x_i'^2 ;$$

in the case of a continuous mass the formula is

$$e = \tfrac{1}{2} \int x'^2 dm .$$

The energy of translation may change, either with or without collisions. Suppose, for example, that two equal masses m_1 subject to the law of gravitation are started moving in the direction of the line joining them with the same speed v. Their kinetic energy is

$$\frac{1}{2}[m_1 v^2 + m_1 v^2] = m_1 v^2 .$$

Their mutual attraction will cause them to move toward one another. Suppose the attraction of each for the other produces after a certain interval of time a speed in each of $\frac{1}{2}v$. The body in advance will then be moving with the speed

$$v - \frac{1}{2}v = \frac{1}{2}v ;$$

and the one in the rear with the speed

$$v + \frac{1}{2}v = \frac{3}{2}v .$$

The energy of the system is then

$$\frac{1}{2}\left[m_1\left(\frac{1}{2}v\right)^2+m_1\left(\frac{3}{2}v\right)^2\right]=\frac{5}{4}m_1v^2.$$

In this case the increase in kinetic energy has been made at the expense of potential energy.

Suppose the two bodies just considered go on to a collision and that at the collision they coalesce. The kinetic energy will be reduced to that at the start, namely $m_1 v^2$. The potential energy will be decreased, but the loss is balanced by the heat generated by the impact of the two bodies.

Now consider the case of a rotating mass or system of masses. It is necessary first to define quantity of rotation, or *moment of momentum*. Suppose there is a set of axes having fixed direction in space with its origin at the center of mass of the system. For simplicity, consider the moment of momentum about one axis, say the z-axis. Let the distance of the mass m_1 from the z-axis be represented by D_1, which of course equals $\sqrt{x_1^2+y_1^2}$. Let v_1 represent the component of velocity of m_1 which is parallel to the xy-plane and perpendicular to D_1. Then the moment of momentum of m_1 with respect to the z-axis is $D_1 v_1 m_1$, and the moment of momentum of the whole system with respect to the z-axis

$$M=\sum_{i=1}^{n} D_i v_i m_i .$$

If the mass is continuous the sum is replaced by the integral

$$M=\int D v\,dm.$$

Two things are true about the moment of momentum. (A) If the system is subject to no external force, the moment of momentum about each of the three axes (and also all others) is constant. This is true if the system is composed of isolated masses which do not collide; it is true if the isolated masses collide; and it is true for a continuous mass, whatever internal frictional currents there may be. (B) Suppose the system is subject to an external force F, parallel to xy-plane, and consider its effect on the moment of momentum about the z-axis. Let P be the perpendicular distance from the z-axis to the line of the external force F. The moment of the force F with respect to the z-axis is PF. The rate of change of moment of momentum of the system about the z-axis is directly proportional to PF. Similarly for any number of forces. In short, the moment of momentum of a system of bodies, or of a continuous mass, about an axis can be changed only by

an external force having a moment about that axis, and the rate of change of the moment of momentum is directly proportional to the moment of the external force.

Consider some applications. Sir George Darwin treated the earth-moon system as modified by the mutual tides of these bodies. In spite of the heat generated in the earth by the tides, he maintained, of course quite correctly, that the moment of momentum was not thereby altered. The matter is set forth in the second volume of Thomson and Tait's Natural Philosophy. On the other hand, the energy of the system could diminish, and in fact the diminution of it is a direct measure of the extent of the effects of the tides. In other words, if there is no change in the energy of the system there is no tidal evolution.

It is sometimes supposed that a planet may have originally rotated in one direction and that tides may have caused it to rotate in the opposite. That is, the planet considered as a system has been subject to an external force (from a satellite, another planet, or the sun), and the sign of its momentum about an axis perpendicular to the plane of its orbit has been supposed to have been changed. This can have been brought about only by forces having a moment about an axis perpen- to the plane of the orbit of the planet. If these simple principles are borne in mind many false conclusions will be avoided.

University of Chicago.

November 27, 1917.

THE SUN'S INTERIOR FRICTION.

A Reply to the foregoing article by Professor Moulton.

N. JOHANNSEN.

I dare say Professor Moulton would not have written the way he did, if he had been in possession of the "Addenda," published in January, in a booklet entitled "The Birth of a Planet", together with a reprint of the articles which appeared in "Popular Astronomy." Another professor, well known, had sent me his criticism before, and I saw that I had not brought out my points with sufficient clearness; therefore the Addenda, which give additional evidence in support of them.

Professor Moulton speaks of various points which are not disputed. He brings out an array of algebra, in regard to which I say that all algebra is worthless unless the starting parts are right, and the starting

points are not brought out by algebra. The whole controversy hinges on the question of frictional effect (to which effect I ascribe the gradual waning of the sun's rotary momentum), and this fundamental point he disposes of in a by-way, in a single line, reading: "and it is true for a continuous mass, whatever internal frictional currents there may be." This is the only proof he has to give; he says: "it is true"—whereas I have given a number of proofs showing that it is not true. If he would tackle these proofs of mine, and show them to be untenable, there would have been no necessity to add other points which are not disputed.

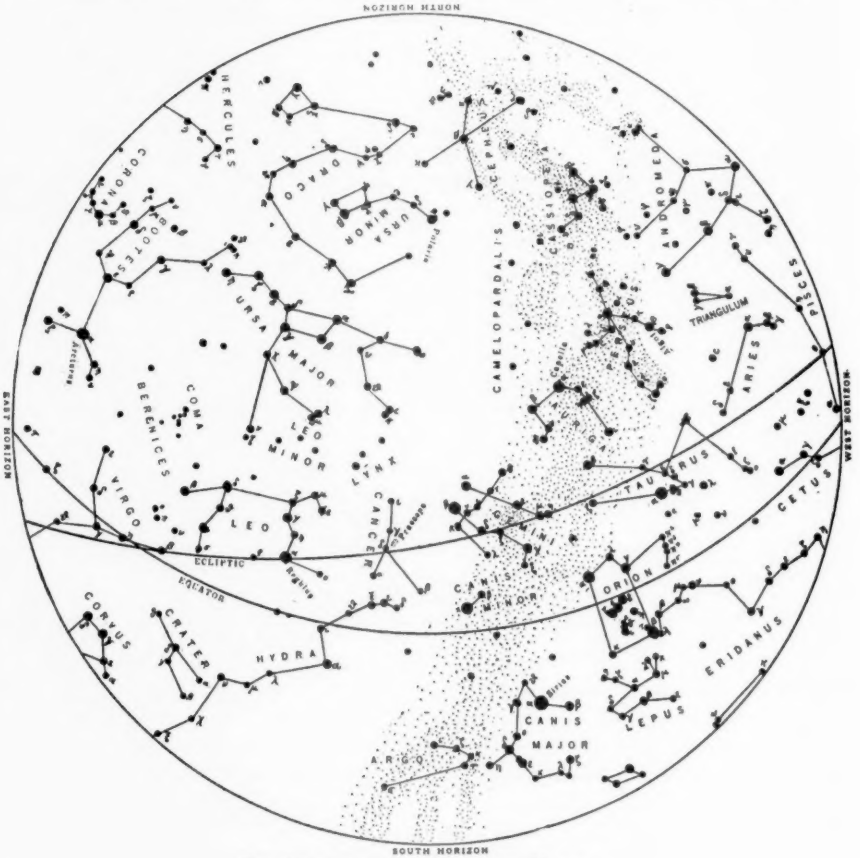
I repeat my main point as follows: The sun's interior convection currents, especially those at or near the equator, do not rise in a straight line. They are deflected sideways when reaching higher, quicker-moving strata. The lateral momentum thus imparted to them is supplied by, and taken from, the fund of the sun's angular momentum. The momentum thus supplied would be fully restored to that fund by the descending currents, provided there were no friction. And in that case Professor Moulton's view would be right. It may seem as though the friction of the upward currents would neutralize that of the downward currents, but the reverse is true, the two frictions do not counterbalance each other but *add to* each other. If each current moves with a momentum of 100 units, and loses 10 units on its way by friction, restoring only 90 units to the general fund, it is clear that the sun's angular momentum must gradually be eaten up.

Now consider the effect of each individual current by itself. If it loses momentum of its own, owing to friction, it will impart momentum to the surrounding material, which it pulls along. But here a new point comes into play, namely: friction always causes some of the moving body's energy to be transformed into heat. If the current loses 10 units of its momentum (or energy) by friction, these 10 units cannot do both, transfer 10 units of momentum to the surrounding material and, in addition, be transformed into heat. Part of the 10 units will do the one, and the remaining part the other—making a full restitution of the 10 units to the sun's general fund of momentum impossible.

Mathematicians have brought out the strange theory that momentum and kinetic energy are entirely different things; according to which theory the 10 units of kinetic energy which the current loses, would not involve a loss of 10 units of *momentum*. Somewhat like eating a pudding and have it too. I have dealt with this theory on pages 23 and 24 of my booklet.

PLANET NOTES FOR MARCH, 1918.

The sun will move in a northeasterly direction from Capricornus into Pisces. It will not pass near any bright stars, but will pass an important point in the sky, namely the vernal equinox. This is the point of intersection of the sun's path and



THE CONSTELLATIONS AT 9:00 P. M. MARCH 1.

the equator. It is the point used by astronomers as the starting point for determining distance east and west in the sky. Its interest for people in general is in the fact that, if the sun should remain at that point, the days and nights would be of equal length. For people living north of the equator the passing of this point

by the sun means longer days and shorter nights and the date is assigned by the almanacs as the beginning of spring. This year this passage occurs in the morning of Tuesday March 21.

The phases of the moon for this month are as follows:

Last Quarter	Mar.	5	at 7	P.M.	C.S.T.
New Moon		12	" 2	P.M.	"
First Quarter		19	" 8	A.M.	"
Full Moon		27	" 10	A.M.	"

Mercury will be moving eastward throughout the month. On March 12 it will pass the sun on the opposite side from the earth. It will therefore not be visible in the early part of the month. By the end of the month it will be approaching a point of greatest elongation east and may be visible on the western horizon at sunset.

Venus, having been passed by the sun on February 9, will move eastward slowly and will be falling continually farther and farther west of the sun. It will be a morning star throughout the month, reaching its greatest brilliancy on March 16.

Mars will be coming into good position. On March 14 it will be in opposition On this date it will rise at sunset and after this date it will rise before sunset. Mars will therefore be a bright object in the east in the evening. It will be nearly as bright as Sirius although quite different from it in color.

Jupiter will continue to be a bright object in the western sky in the evening At the close of the month it will be on the meridian a little before four o'clock.

Saturn will be in its best position for the year. About the middle of the month it will cross the meridian at nine in the evening.

Uranus will be a short distance west of the sun. Near the end of the month it will become visible in the southeast just before sunrise.

Neptune will be in the same part of the sky as Saturn. It will therefore also be in favorable position for those who are interested in this, the most distant planet. It, of course, can be seen only with the aid of a telescope.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1918	Star's Name	Magnitude	IMMERSION. Washington M.T. h m	IMMERSION. Angle from N. °	EMERSION. Washington M.T. h m	EMERSION. Angle from N. °	Duration h m
Mar. 1	83 G Virginis	5.6	12 30	149	13 41	272	1 10
4	19 Scorpii	4.9	14 0	121	15 14	269	1 14
17	72 Tauri	5.4	7 48	109	8 55	254	1 7
19	μ Gemin.	3.2	7 33	72	8 42	318	1 10
28	75 Virginis	5.6	13 49	174	14 39	242	0 50
29	43 H Virginis	5.5	9 24	146	10 24	266	1 0
29	236 G Virginis	5.7	12 2	187	12 32	229	0 30
31	57 B Scorpii	5.7	14 5	100	15 35	285	1 30
31	27 G Scorpii	5.8	15 55	90	17 24	282	1 30

Encke's Comet Rediscovered.—A cablegram received at this Observatory from Copenhagen states that Encke's Comet was observed by Professor Schorr, of the Bergedorf Observatory, December 30.2271 G. M. T. in R. A. $22^h\ 59^m\ 4^s.9$, Dec. $+3°\ 17'\ 35''$.

EDWARD C. PICKERING,
Director.

Harvard College Observatory, Bulletin 647.
Cambridge, Mass., U. S. A.
January 2, 1918.

Phenomena of Jupiter's Satellites.

VISIBLE AT WASHINGTON.

[*From the American Ephemeris.*]

CENTRAL STANDARD TIME.

1918	h	m			1918	h	m		
Mar. 2	9	10	I	Oc. D.	Mar. 14	9	31	II	Ec. R.
3	6	20	I	Tr. I.	17	10	15	I	Tr. I.
	7	38	I	Sh. I.	18	7	35	I	Oc. D.
	8	31	I	Tr. E.		10	11	III	Oc. D.
	9	48	I	Sh. E.	19	5	57	I	Sh. I.
4	7	9	III	Ec. D.		8	55	I	Tr. E.
	7	10	I	Ec. R.		8	8	I	Sh. E.
	9	30	III	Ec. R.	21	7	9	II	Oc. D.
5	7	34	II	Tr. I.	22	7	40	III	Sh. E.
	10	6	II	Tr. E.	23	7	17	II	Sh. E.
	10	12	II	Sh. I.	25	9	34	I	Oc. D.
7	6	54	II	Ec. R.	26	6	43	I	Tr. I.
10	8	17	I	Tr. I.		7	53	I	Sh. I.
	9	33	I	Sh. I.		8	54	I	Tr. E.
	10	28	I	Tr. E.	27	7	26	I	Ec. R.
11	6	0	III	Oc. D.	29	7	4	III	Tr. E.
	8	21	III	Oc. R.		9	18	III	Sh. I.
	9	6	I	Ec. R.	30	7	23	II	Sh. I.
12	6	12	I	Sh. E.		7	40	II	Tr. E.
	10	15	II	Tr. I.					

Note:—I., denotes ingress; E., egress; D., disappearance; R., reappearance; Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Satellites of Saturn, March 1918.

[From the *American Ephemeris.*]

CENTRAL STANDARD TIME.

I. Mimas. Period $0^d\ 22^h.6$.

	h		h		h		h	
Mar. 1	15.8	E	Mar. 8	17.4	W	Mar. 16	6.3	W	Mar. 23	7.9	E
2	14.4	E	9	16.0	W	16	17.7	E	24	6.6	E
3	13.0	E	10	14.6	W	17	16.3	E	25	16.5	W
4	11.6	E	11	13.2	W	18	14.9	E	26	15.1	W
5	10.2	E	12	11.9	W	19	13.5	E	27	13.7	W
6	8.8	E	13	10.5	W	20	12.1	E	28	12.4	W
7	7.4	E	14	9.1	W	21	10.7	E	29	11.0	W
8	6.1	E	15	7.7	W	22	9.3	E	30	9.6	W
									31	8.2	W

II. Enceladus. Period $1^d\ 8^h.9$.

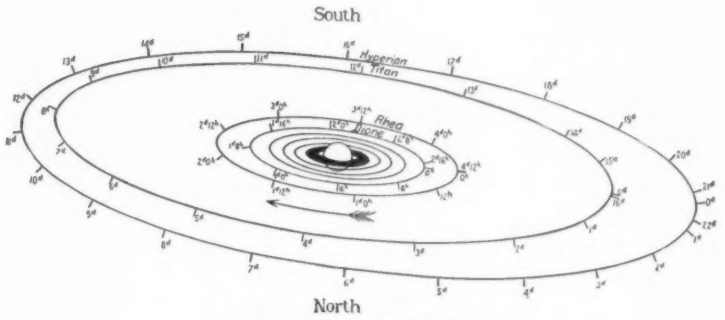
Mar. 1	12.6	E	Mar. 9	17.9	E	Mar. 17	23.2	E	Mar. 26	4.5	E
2	21.5	E	11	2.8	E	19	8.1	E	27	13.4	E
4	6.4	E	12	11.7	E	20	17.0	E	25	22.3	E
5	15.3	E	13	20.6	E	22	1.9	E	30	7.2	E
7	0.2	E	15	5.5	E	23	10.8	E	31	16.1	E
8	9.0	E	16	14.3	E	24	19 6	E			

III. Tethys. Period $1^d\ 21^h.3$.

Mar. 1	17.7	E	Mar. 9	6.9	E	Mar. 16	20.1	E	Mar. 24	9.3	E
3	15,0	E	11	4.2	E	18	17.4	E	26	6.6	E
5	12.3	E	13	1.5	E	20	14.7	E	38	3.9	E
7	9.6	E	14	22.8	E	22	12.0	E	30	1.2	E

IV. Dione. Period $2^d\ 17^h.7$.

	h		h		h		h
Mar. 1	7.5 E	Mar. 9	12.6 E	Mar. 17	17.6 E	Mar. 25	22.7 E
4	1.2 E	12	6.3 E	20	11.3 E	28	16.3 E
6	18.9 E	14	23.9 E	23	5.0 E	31	10.0 E



SATELLITES OF SATURN, 1918.

Apparent Orbits of the Seven Inner Satellites of Saturn at Date of Opposition, January 31, 1918, as seen in an inverting telescope.

V. Rhea. Period $4^d\ 12^h.5$.

Mar. 4	12.6 E	Mar. 13	13.3 E	Mar. 22	14.1 E	Mar. 31	14.9 E
9	1.0 E	18	1.7 E	27	2.5 E		

VI. Titan. Period $15^d\ 23^h.3$.

Mar. 5	17.9 W	Mar. 13	23.3 E	Mar. 21	15.9 W	Mar. 29	21.5 E

VII. Hyperion. Period $21^d\ 7.6^h$.

Mar. 7	19.4 E	Mar. 19	5.3 W	Mar. 29	2.9 E

VIII. Iapetus. Period $79^d\ 22^h.1$.

Mar. 5	2.9 I	Mar. 23	18.8 W

IX. Phoebe. Period $523^d\ 15^h.6$.

	α Ph.—α Sat.	δ Ph.—δ Sat.		α Ph.—α Sat.	δ Ph.—δ Sat.
	m s	′ ″		m s	′ ″
Mar. 1	−1 10.1	+1 59	Mar. 17	−0 42.1	+0 10
3	1 6.8	1 46	19	0 38.5	−0 3
5	1 3.4	1 32	21	0 34.8	0 16
7	1 0.0	1 18	23	0 31.1	0 29
9	0 56.5	1 4	25	0 27.3	0 42
11	0 53.0	0 51	27	0 23.6	0 55
13	0 49.4	0 37	29	0 19.8	1 8
15	−0 45.5	+0 24	31	−0 16.1	−1 21

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and Franz Exner at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1918 March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			18 6					
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	2 13;	10 5;	17 21;	25 13				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	2 14;	10 0;	17 10;	24 21				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	3 0;	10 12;	17 23;	25 11				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	5 1;	11 4;	23 9;	29 12				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	1 17;	8 20;	23 3;	30 6				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	2 9;	9 6;	22 23;	29 20				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	7 17;	14 21;	22 2;	29 6				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	7 5;	16 0;	24 17					
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	4 17;	12 16;	20 14;	28 13				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6			26 20					
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	3 11;	9 5;	20 16;	26 10				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	1 8;	8 3;	21 18;	28 13				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	4 1;	11 23;	19 20;	27 18				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	8 21;	17 5;	25 12					
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	7 20;	15 18;	23 15;	31 13				
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	1 18;	14 23;	28 4					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	2 7;	11 17;	21 4;	30 15				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	8 9;		20 19					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	5 2;	11 17;	25 1;	31 17				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	4 8;	12 12;	20 17;	28 21				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	6 4;	12 4;	24 5;	30 6				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	3 8;	12 0;	20 16;	29 8				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	4 19;	15 4;	25 14					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	6 17;	14 17;	22 17;	30 18				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	5 4;	10 22;	22 9;	28 2				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	1 6;	12 11;	23 16;	29 6				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	8 5;	16 10;	24 15					
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	7 13;	15 4;	22 19;	30 10				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	3 22;	16 3;	28 8					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	5 21;	13 1;	20 5;	27 9				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	7 8;	14 3;	20 23;	27 18				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	8 3;	17 10;	26 17					
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	1 18;	8 8;	21 14;	28 4				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	1 10;	9 20;	18 5;	26 15				
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	4 18;	11 5;	24 1;	30 12				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	7 21;	15 4;	22 11;	29 17				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	1 23;	10 2;	18 5;	26 8				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	5 1;	14 13;	24 0					
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	7 20;	14 16;	21 12;	28 9				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	1 21;	13 18;	25 15;	31 13				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	2 22;	9 16;	23 4;	29 22				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3 8;	10 18;	18 4;	25 14				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	6 20;	13 10;	20 1;	26 15				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	8 0;	16 19;	25 14					
RW Urs. Maj.	35.4	−52 34	10.3—11.4	7 07.9	1 21;	9 5;	23 21;	31 4				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	7 0;	13 19;	20 14;	27 9				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	4 3;	11 15;	19 3;	26 15				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	6 22;	16 12;	26 2					
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	4 17;	12 4;	19 14;	27 1				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	5 10;	12 9;	18 9;	26 8				

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1918 March
	h m	° ′		d h	d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	4 1; 10 22; 17 20; 24 18
TW Draconis	32.4	+64 14	7.3— 8.9	2 9.12	6 17; 15 3; 23 13; 31 23
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	7 8; 14 23; 22 15; 30 7
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	3 11; 10 19; 18 3; 25 11
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	2 5; 10 11; 18 17; 27 0
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	1 2; 9 23; 18 19; 27 16
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	7 18; 18 19; 28 12
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	5 13; 12 8; 19 4; 25 23
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	6 20; 15 5; 23 15
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	6 21; 13 0; 25 8; 31 11
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	3 11; 10 16; 17 21; 25 2
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	6 18; 14 3; 21 12; 28 21
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	8 16; 16 10; 24 14
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	7 21; 15 10; 22 23; 30 12
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	6 4; 13 22; 21 15; 29 9
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	5 19; 13 19; 21 18; 29 18
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	6 18; 15 7; 23 19
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	3 21; 13 5; 22 13; 31 21
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	7 20; 18 4; 28 12
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	6 1; 13 6; 20 12; 27 18
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	1 17; 8 15; 22 11; 29 8
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	14 2; 29 5
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	5 7; 12 11; 19 15; 26 19
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	2 22; 10 1; 24 7; 31 9
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	8 22; 17 6; 25 13
RR Draconis	40.8	+62 34	9.3—13	2 19.9	2 12; 10 23; 19 11; 27 23
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	2 22; 9 13; 22 20; 29 11
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	4 5; 17 3; 30 1
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	7 8; 14 23; 22 15; 30 6
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	3 1; 10 15; 18 4; 25 18
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	1 4; 8 8; 22 18; 29 23
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	9 22; 18 21; 27 20
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	7 10; 14 4; 20 23; 27 17
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	7 21; 15 6; 22 14; 29 23
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	4 13; 15 0; 25 12; 30 18
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	3 16; 10 5; 23 6; 29 18
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	1 5; 13 5; 25 5; 31 6
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	2 23; 9 14; 22 21; 29 12
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	7 4; 16 7; 25 11
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	6 17; 15 4; 23 14
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	5 13; 12 8; 19 3; 25 21
UW Cygni	19.6	+42 55	10.5—10.8	3 10.8	4 2; 11 0; 24 19; 31 17
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	11 5;
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	5 13; 15 3; 24 18
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	2 21; 12 2; 21 6; 30 11
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	5 5; 12 17; 20 4; 27 16
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	3 17; 11 7; 18 22; 26 12
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	8 1; 18 3; 28 5
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	4 10; 11 19; 19 5; 26 14
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	2 6; 11 23; 21 15; 31 8
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	7 7; 15 4; 23 1; 30 22
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	3 10; 13 14; 23 17
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	7 5
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	1 6; 6 10; 16 19; 27 4
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	8 19; 17 2; 25 9
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	5 1; 12 14; 20 3; 27 16
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	1 20; 10 2; 18 7; 26 13

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5^h; Central standard time 6^h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1918. March							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7				25 14				
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	2 22;	11 1;	19 4;	27 8				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	4 23;	12 17;	20 11;	28 5				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2		12 17;		27 3				
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	2 11;	10 9;	18 8;	26 6				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	3 23;	11 18;	19 13;	27 8				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	6 21;	14 4;	21 11;	28 18				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		12		28				
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	2 2;	10 16;	19 6;	27 20				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	6 3;	17 6;	28 9					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0		10 22;	22 13					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	6 12;	14 4;	21 19;	29 11				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	2 1;	12 4;	22 8					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	3 19;	11 12;	19 5;	26 23				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	5 15;	11 4;	22 5;	27 18				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	3 21;	11 11;	19 0;	26 14				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	1 1			28 2				
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	1 14;	9 1;	23 23;	31 10				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	5 6;	12 11;	19 16;	26 21				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	4 8;	12 6;	20 4;	28 2				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	4 12;	14 16;	24 19					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	12 06.5			20 3					
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	1 7;	9 5;	17 14;	25 3				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	1 22;	8 15;	22 0;	28 17				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	3 20;	13 3;	22 9;	31 16				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	3 16;	12 10;	21 4;	29 21				
Z Leonis						7						
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	4 21;	11 16;	18 11;	25 6				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	5 14;	12 4;	18 19;	25 9				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8		10 13;	20 5;	29 20				
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	6 12;	14 12;	22 11;	30 11				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	6 13;	13 6;	20 0;	26 18				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	3 2;	8 21;	20 13;	26 9				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	5 10;	14 19;	24 4;	28 21				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	1 16		18 23					
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	6 5;	14 10;	22 15;	30 20				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	6 17;	13 18;	20 18;	27 19				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	4 14;	12 19;	21 0;	29 5				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	3 17;	9 5;	20 5;	31 4				
RS Bootis	29.3	+32 11	8.6—10.0	0 09.1	8 12;	16 1;	23 14;	31 3				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	8 7;	15 17;	23 3;	30 13				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	4 22;	11 17;	18 12;	25 6				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	3 8;	9 16;	22 7;	28 15				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	8 4;	17 22;	27 16					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	6 12;	15 8;	24 5					
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	5 22;	11 4;	23 7;	29 8				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	7 3;	14 3;	21 4;	28 4				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	1 15;		18 18					
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	8 7;	15 21;	23 11;	31 1				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	5 9;	11 4;	22 17;	28 12				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.5	6 13;	13 7;	20 1;	26 19				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	3 8;	13 16;	24 0					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	6 20;	12 21;	24 23;	31 0				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1918. March							
	h m	° ′		d h	d h	d h	d h	d h				
RZ Lyrae	18 39.9	+32 42	9.9—11.2	0 12.3	6 0;	12 3;	24 10;	30 13				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	1 13;	7 12;	19 9;	31 7				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	4 3;	13 5;	22 7;	31 9				
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	1 8;	8 10;	22 11;	29 12				
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	6 1;	13 1;	20 1;	27 1				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	8 14;	16 14;	24 13					
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	2 15;	10 8;	18 0;	25 17				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	6 3;	13 7;	20 12;	27 16				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	3 6;	11 15;	20 0;	28 10				
X Vulpec.	19 53.3	+26 17	9.51—0.5	6 07.7	6 21;	13 5;	19 13;	25 20				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	7 11;		23 21					
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	3 11;	12 7;	21 4;	30 1				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	7 0;	13 17;	20 11;	27 4				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	4 18;	11 11;	24 21;	31 14				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		13 21		28 15				
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	7 5;	15 2;	22 22;	30 19				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	3 20;	10 17;	24 12;	31 9				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4 22;	14 15;	24 8;	29 5				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	2 16;	11 8;	19 23;	28 15				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	3 12;	8 21;	19 15;	25 0				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1		10 7;	21 4					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	3 7;	9 17;	16 3;	29 0				
V Lacertae	22 44.5	+55 48	8.5— 9.5	4 23.6	2 2;	7 2;	17 1;	27 0				
X Lacertae	45.0	+55 54	8.2— 8.6	5 10.7	3 3;	8 13;	19 11;	30 8				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	2 7;	7 17;	18 14;	29 12				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	5 12;	11 19;	24 10;	30 17				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4		12 8		24 12				
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	1 19;	11 18;	21 18;	31 17				

NOTES FOR OBSERVERS.

Report of the American Association of Variable Star Observers, December-January, 1917-18.

In spite of the inclement weather during the past month and a protracted period of extreme cold in the east which has greatly hampered our work we have, during the past month, maintained a good average number of observations and observed a large number of Variables.

It is a pleasure to welcome as Charter Members of the Association the following observers:—

Miss M. Alberta Hawes, of the Harvard College Observatory staff.
Mr. Eugene Middleton, of Glendale, Cal.
Mr. Frederick Ray, of New York City.
Mr. R. M. Motherwell, of the Dominion Observatory staff, Ottawa, Canada.

Mr. Motherwell is an experienced observer of variable stars and a valuable addition to our ranks.

Mr. Bernard Dawson of the National Observatory of La Plata, Argentina, contributes to this report a valuable set of observations of southern variables exclusively. It is gratifying to note that many of the heretofore neglected southern variables are

VARIABLE STAR OBSERVATIONS Dec.-Jan., 1917-18.

November 0 = 2421533 December 0 = 2421563 January 0 = 2421594

001032
S Sculptoris

J.D. 242	Est.	Obs.
1521.7	11.4	δ
23.7	11.3	δ
38.6	10.7	δ
49.7	9.7	δ
71.2	9.0	L
72.7	8.7	Me

001046
X Androm.

1569.5	<12.5	De
71.7	14.0	Me
79.6	<11.1	V

001620
T Ceti

1507.4	6.3	Lt
13.3	6.2	Lt
16.4	5.9	Lt
20.4	5.8	Lt
22.5	5.7	Lt
32.6	5.8	L
71.2	5.8	L

001726
T Androm.

1565.6	11.7	Wh
66.7	11.6	Me
92.5	9.6	Sp

001755
T Cassiop.

1558.5	9.7	B
64.8	9.8	M
70.7	10.2	Me
71.7	10.0	Bg

001838
R Androm.

1507.4	9.2	Lt
13.3	9.5	Lt
50.3	10.0	Pe
69.5	11.5±	De
70.6	10.3	Hu
70.7	10.2	Me
73.5	11.0	Pi
73.6	11.6	V

001909
S Ceti

1513.3	10.0	Lt
21.7	10.1	δ
38.6	11.3	δ
50.3	<10.5	De
65.5	<10.2	M
70.6	12.5±	De
72.6	11.0	Hu
73.5	<10.2	Pi
75.7	<11.8	Bg

003179
Y Cephei

J.D. 242	Est.	Obs.
1513.3	10.1	Lt
20.5	10.2	Lt
69.5	11.4	De
69.6	11.7	Wh
72.6	11.5	Hu

004047
U Cassiop.

1568.7	11.4	Me
70.5	11.6	Y
77.6	9.8	B
78.7	10.7	Wh

004132
RW Androm.

1569.6	10.4	De
70.6	10.3	Wh
78.6	10.8	De

004435
V Androm.

1570.6	10.2	Hu
79.6	9.8	V

004746
RV Cassiop.

1578.7	<11.5	Wh

004958
W Cassiop.

1564.8	10.5	M
70.6	10.6	Wh
74.5	11.1	De
85.5	10.7	B

010102
Z Ceti

1513.3	9.5	Lt
20.4	9.9	Lt

010940
U Androm.

1572.6	11.3	Hu

011208
S Persei

1566.7	14.0	Me
69.6	<13.6	Y

011272
S Cassiop.

1569.6	<12.3	Wh
72.7	<13.0	Me

011712
U Piscium

1567.6	11.6	De
78.6	11.6	De

*012233*a
R Sculptoris

1552.3	6.0	L

012350
RZ Persei

J.D. 242	Est.	Obs.
1570.5	<13.0	Y

012502
R Piscium

1503.4	9.2	Lt
13.4	9.5	Lt
16.3	<9.3	Vo
65.6	11.7	Wh
69.6	11.2	Y
70.8	11.5	By
72.5	<11.5±	De

013338
Y Androm.

1570.6	12.0	Hu

014958
X Cassiop.

1564.8	<11.2	M
70.5	12.6	Y
70.5	11.1	De

015354
U Persei

1513.4	8.3	Lt
20.3	8.7	Vo
64.8	8.9	M
71.8	8.9	Bg
72.6	8.9	Hu
78.7	9.7	Wh
85.5	9.5	De
85.6	9.2	B

015912
S Arietis

1574.6	<12.0	De

021024
R Arietis

1507.3	8.7	Vo
13.3	9.8	Lt
16.4	8.9	V
20.3	8.9	Vo
20.4	9.8	Lt
23.3	8.9	Vo
27.4	9.8	Lt
47.3	9.5	Pe
50.3	10.1	Pe
71.8	i1.3	Bg
78.7	11.6	De

021558
S Persei

1573.5	9.2	B

021403
o Ceti

1503.4	3.9	Lt
03.4	3.7	Vo
04.3	3.4	Lt
04.4	3.7	Vo
07.4	3.4	Lt
08.4	3.6	Vo

o Ceti

J.D. 242	Est.	Obs.
1508.4	3.4	Lt
09.4	3.4	Lt
13.4	3.8	Vo
13.4	3.4	Lt
16.4	3.7	Vo
16.4	3.5	Lt
20.4	3.7	Lt
20.4	3.9	Vo
21.4	3.9	Vo
21.4	3.7	Lt
21.7	3.9	δ
22.3	3.9	Vo
22.5	3.8	Lt
23.4	3.9	Vo
24.6	3.6	L
27.3	3.9	Lt
27.4	3.9	Vo
28.3	4.0	Vo
31.5	4.0	Lt
35.3	3.6	L
37.3	3.8	L
38.3	4.3	Pe
38.5	4.0	δ
41.3	4.3	Pe
42.7	4.0	δ
44.3	4.4	Pe
45.6	4.1	δ
47.3	4.3	Pe
49.3	4.3	Pe
49.7	4.0	δ
49.2	3.8	Be
52.2	4.0	Be
52.3	4.5	Pe
52.3	3.7	L
53.3	3.7	L
55.2	4.0	Be
55.3	3.7	L
65.7	4.4	Mu
66.3	3.8	L
66.6	4.3	Mu
67.7	4.4	Mu
68.7	4.4	Mu
68.2	4.1	Be
68.6	4.5	Mu
68.7	4.4	Me
69.6	4.5	Mu
70.6	4.5	Mu
70.7	4.4	Me
70.8	4.5	By
71.6	4.6	Mu
72.6	4.0	Hu
73.5	4.8	Pi
73.7	4.6	Mu
73.7	4.7	Me
74.7	4.8	Mu
75.7	4.8	Mu
77.7	4.8	Mu
80.7	4.8	Mu
92.5	5.2	Nt

022000
R Ceti

J.D. 242	Est.	Obs.
1493.6	<13.0	Lt
1520.5	9.2	Lt
27.4	8.1	Lt
49.3	8.9	Pe

022150
RR Persei

1570.5	10.2	Y
85.5	11.0	De

022813
U Ceti

1520.4	8.5	Lt
21.7	8.8	δ
45.6	9.0	δ
49.7	9.4	δ
73.6	10.3	Pi
74.6	11.4	V

023133
R Trianguli

1503.3	6.6	Vo
07.4	7.1	Lt
13.3	7.6	Lt
13.4	7.0	Vo
16.3	7.2	Vo
20.3	7.7	Vo
23.4	7.8	Vo
65.6	9.9	M
72.6	9.5	Hu
73.6	10.0	Pi
85.6	11.0	B

024217
T Arietis

1520.5	9.7	Lt
37.3	9.7	L
53.3	9.5	L

024356
W Persei

1565.6	9.0	M
72.6	8.6	Hu
74.7	9.0	Mu

030514
U Arietis

1569.6	<13.1	Y
75.7	15.0	Me

031401
X Ceti

1574.7	10.3	Mu
90.7	10.7	Me

032043
Y Persei

1520.3	9.5	Vo
65.6	9.7	M
74.6	8.9	Hu
74.7	10.3	Mu
85.5	10.3	De

VARIABLE STAR OBSERVATIONS, Dec.-Jan., 1917-18—Continued.

032335
R Persei
J.D. Est. Obs.
242
1573.7 9.7 Me
74.6 9.0 Hu
78.6 9,0 Hu

033362
U Camelop.
1513.3 8.5 Lt
20.3 8.5 Lt

035915
V Eridani
1521.7 9.1 δ
38.7 9.0 δ
45.6 9.1 δ
67.6 9.6 De
90.7 8.6 Me

041619
T Tauri
1565.6 9.7 M

042209
R Tauri
1570.7<13.4 Me

042215
W Tauri
1538.3 10.9 Pe
41.3 10.9 Pe
44.3 11.1 Pe
47.3 11.2 Pe
67.3 11.9 De
69.6 12.1 Y
73.6<11.4 Pi
74.5<12.3 B
74.6<12.0 Hu
74.7<10.4 Mu
75.7<10.4 V
78.7<12.1 Wh

042309
S Tauri
1570.7<13.4 M

043065
T Camelop.
1576.7<13.2 Me

043208
RX Tauri
1573.6 10.8 Pi
74.6 10.6 Hu
78.6 10.6 Hu
85.5 11.1 B
85.6 10.7 De

043274
X Camelop.
1513.3 8.2 Lt
20.5 8.2 Lt
69.6 11.4 Wh
70.5 12.0 Y
75.5<11.1 V
76.7<11.5 Bg

044617
V Tauri
J.D. Est.Obs.
242
1583.8 12.0 M
85.6<11.9 B
85.6 12.3 De

045307
R Orionis
1575.6 12.9 Y
75.6<12.3 B

045514
R Leporis
1521.7 8.5 δ
45.6 8.3 δ
49.7 9.0 L
67.7 8.7 De
68.3 8.9 L
73.7 9.2 Me
87.5 7.1 B

050022
T Leporis
1521.7 10.9 δ
23.7 10.9 δ
45.7 10.9 δ
83.8 9.4 M
90.7 9.0 Me

050003
V Orionis
1573.6<12.0 Pi
75.6<13.0 Y
75.6<12.5 B
77.7<12.7 Me
83.7<12.3 Wh

050953
R Aurigae
1503.3 8.0 Lt
13.3 7.4 Lt
17.3 7.4 Lt
20.3 7.4 Lt
67.7 8.3 De
73.5 8.5 B
79.6 8.5 V
87.6 8.8 B

052034
S Aurigae
1556.3<10.5 Pe
74.7 9.6 Mu
78.6 8.8 B
93.6 9.2 Wh

052036
W Aurigae
1578.6 11.0 Hu
78.6 10.6 B

052404
S Orionis
1565.6 10.3 De
75.5 10.6 B
82.8 10.0 M
85.5 10.1 De

053068
S Camelop.
J.D. Est.Obs.
242
1585.6 10.7 De

*053005*a
T Orionis
1544.3 10.8 Pe
47.3 10.9 Pe
52.4 11.0 Pe
52.7 10.3 L
65.6 10.8 De
70.7 10.7 Me
71.8 10.8 By
75.5 11.5 B
78.8 11.0 By
85.6 11.0 De

053531
U Aurigae
1570.6 9.8 Y
78.6 10.1 B
79.6 9.5 V

054319
SU Tauri
1524.6 9.5 L
49.7 9.5 L
52.7 9.6 L
56.3 9.9 Pe
57.7 9.4 L
65.6 10.0 De
68.3 9.2 L
70.5 9.4 Y
71.3 9.7 L
73.6 9.4 Pi
74.5 10.0 B
75.5 9.7 B
77.6 9.5 B
78.6 9.4 De
79.6 9.9 V
83.6 9.4 V
83.8 9.0 M
83.6 9.5 Wh
85.6 9.5 B
87.5 9.5 B
88.5 9.5 B

054615
RU Tauri
1575.6 12.5 Y

054615a
Z Tauri
1575.6 13.1 Y

054920
U Orionis
1552.2 11.1 Pe
55.4 11.0 Pe
73.6 10.6 Pi
74.6 11.0 B
76.7 11.4 Bg
78.6 11.0 Hu
83.8 11.5 M

054974
V Camelop.
J.D. Est.Obs.
242
1569.6<12.2 Wh
78.6<12.6 B
81.7 14.0 Me
83.6<12.2 Wh
83.8<12.2 M
93.6<12.2 Wh

055353
Z Aurigae
1513.3 9.8 Lt
20.5 9.8 Lt

060124
S Leporis
1523.7 6.4 δ
38.7 6.0 δ

060450
X Aurigae
1513.3 9.0 Lt
20.5 9.4 Lt
65.5 10.0 Pi
65.6<10.5 M
73.5 9.9 De
93.6<11.9 Wh

060547
SS Aurigae
1524.6<12.4 L
36.3 11.4 L
37.3 11.7 L
49.3<12.4 L
57.7<11.5 L
65.5<11.6 Pi
65.6<12.4 De
66.5<11.0 De
66.6<12.4 Y
68.3<12.4 L
70.5<12.4 De
70.7<13.2 Me
71.3<12.4 L
72.6<12.4 De
73.6<11.4 Pi
73.6<12.4 De
73.7<12.4 Me
74.6<12.4 De
77.5<12.4 B
78.6<12.4 De
83.6<11.0 V
85.5<12.4 De

061702
V Monoc.
1523.7 7.3 δ
45.7 6.5 δ
57.8 9.5 By

062808
Z Monoc.
1523.7 8.7 δ
27.8 8.5 δ
38.7 8.6 δ
45.7 8.3 δ

063159
U Lyncis
J.D. Est. Obs.
242
1570.5 9.4 Y
78.6 9.1 B

063308
R Monoc.
1569.7 11.8 De

063558
S Lyncis
1585.6<12.0 B
93.6<11.7 Wh

064030
X Gemin.
1583.6 8.6 V

065111
Y Monoc.
1520.5 10.2 Lt
75.6 10.5 Y
83.6<11.2 V

065208
X Monoc.
1523.7 9.2 δ
27.8 9.2 δ
38.7 9.1 δ
45.7 8.6 δ
49.7 8.8 L
71.8 8.5 By

065355
R Lyncis
1570.5 12.4 Y
82.7 11.6 Me

*070122*a
R Gemin.
1516.4 6.8 Lt
20.5 6.9 Lt
22.4 6.8 Vo
52.4 7.2 Pe
55.4 7.3 Pe
82.7 8.4 Me
85.7 8.5 Wh

070122b
Z Gemin.
1555.4<12.1 Pe
82.7 13.0 Me
85.7<12.1 Wh

070122c
TW Gemin.
1552.4 8.2 Pe
55.4 8.2 Pe
82.7 8.3 Me
85.7 8.0 Wh

070109
V Can. Min.
1575.6 10.7 Y

VARIABLE STAR OBSERVATIONS, Dec.-Jan., 1917-18—Continued.

070310
R Can. Min.

J.D. 242	Est.	Obs.
1555.7	11.2	L
57.7	11.3	L
71.7	11.1	L
88.6	10.2	B

071044
L^2 Puppis

1523.8	5.5	δ
27.8	5.4	δ
38.7	5.0	δ
40.6	4.9	δ
42.7	4.8	δ
45.6	4.8	δ
49.6	4.3	δ

071713
V Gemin.

1585.7	8.3	Wh
88.6	8.4	B

072708
S Can. Min.

1513.5	7.8	Lt
20.5	7.5	Lt
44.4	7.8	Pe
52.4	8.1	Pe
55.4	8.0	Pe
82.8	9.0	M
85.7	8.8	Wh
88.6	9.2	B

073508
U Can. Min.

1549.7	12.1	L
71.7	11.2	L
88.6	10.4	B

073723
S Gemin.

1582.7	10.4	Me
83.7	9.9	V
83.7	10.4	Wh

074323
T Gemin.

1585.7	10.9	Wh
86.7	<11.5	Me

074922
U Gemin.

1524.6	<12.3	L
49.6	<12.4	L
52.7	<10.0	L
55.7	10.4	L
57.7	9.2	L
71.7	<12.4	L
75.6	<13.3	Y
78.6	14.0	Al
83.7	<10.9	V
85.7	<12.3	Wh
85.9	<10.9	M
87.6	<11.2	B
88.6	<11.7	B

075612
U Puppis

J.D. 242	Est.	Obs.
1523.7	<12.3	δ

080322
RU Puppis

1523.7	8.1	δ
27.8	7.9	δ
38.7	8.0	δ
45.7	7.8	δ

081112
R Cancri

1549.7	11.2	L
71.7	10.7	L
85.7	9.6	Wh

081617
V Cancri

1585.7	11.5	Wh

082405
RT Hydrae

1527.8	7.6	δ
45.7	7.8	δ
49.7	7.9	L

083409
RV Hydrae

1527.8	8.3	δ
45.7	7.4	δ

085120
T Cancri

1549.7	9.6	L
71.7	10.0	L

090151
V Urs. Maj.

1524.6	10.2	L
44.4	10.4	Pe
49.3	10.3	L
55.4	10.4	Pe
71.3	10.2	L

092856
N Velorum

1523.8	3.4	δ
24.7	3.4	δ
27.8	3.4	δ
38.7	3.1	δ
40.6	3.2	δ
42.7	3.2	δ
45.6	3.2	δ
48.7	3.0	δ
49.6	3.1	δ
50.6	3.1	δ

092962
R Carinae

1524.7	8.9	δ
27.8	8.5	δ
38.7	8.1	δ
42.7	7.4	δ
45.6	7.1	δ
49.7	7.0	δ

093014
X Hydrae

J.D. 242	Est.	Obs.
1527.8	8.5	δ
45.7	8.7	δ

093178
Y Draconis

1570.5	13.8	Y

093934
R Leo. Min.

1583.8	9.6	M

094262
l Carinae

1523.8	4.1	δ
24.7	4.1	δ
27.8	4.1	δ
38.7	4.4	δ
40.6	4.4	δ
42.6	4.3	δ
45.6	3.9	δ
48.7	3.6	δ
49.6	3.5	δ
50.6	3.4	δ

094211
R Leonis

1549.7	9.4	L
84.8	9.7	M
83.8	10.0	M

094622
Y Hydrae

1527.8	6.8	δ
45.7	6.7	δ

100661
S Carinae

1538.7	8.0	δ
42.7	7.9	δ
45.6	8.4	δ
49.7	8.5	δ

101360
q Carinae

1523.8	3.6	δ
24.7	3.7	δ
27.8	3.6	δ
38.7	3.6	δ
40.6	3.6	δ
42.6	3.5	δ
45.6	3.6	δ
48.7	3.5	δ
49.6	3.4	δ
50.6	3.5	δ

103212
U Hydrae

1549.7	4.7	L

103769
R Urs. Maj.

J.D. 242	Est.	Obs.
1507.4	8.3	Lt
13.3	8.8	Lt
20.3	9.2	Lt
64.8	11.4	M

115905
RX Virginis

1556.7	8.3	L

120206
RW Virginis

1556.7	6.9	L

122001
SS Virginis

1556.7	6.0	L

122532
R Can. Ven.

1585.9	10.1	M

123160
T Urs. Maj.

1503.3	7.8	Lt
07.4	7.8	Lt
13.3	8.1	Lt
13.4	7.7	Vo
16.3	8.2	Lt
16.3	7.8	Vo
20.3	8.1	Lt
64.8	8.2	M
70.8	9.1	Bg
74.4	9.5	Y
85.7	10.0	Wh

123307
R Virginis

1549.7	11.1	L

123459
RS Urs. Maj.

1564.8	<10.9	M
85.7	11.3	Wh

123961
S Urs. Maj.

1503.3	8.5	Lt
07.4	8.3	Lt
13.3	8.3	Lt
16.3	8.2	Lt
20.3	8.3	Lt
25.2	8.0	Lt
57.7	8.6	L
64.9	8.3	M
70.8	8.6	Bg
74.4	8.3	Y
83.8	8.6	M
85.7	8.4	Wh

125705
RT Virginis

1549.7	8.8	L

131546
V Can. Ven.

J.D. 242	Est.	Obs.
1513.3	7.4	Lt

132706
S Virginis

1556.7	10.0	L

134440
R Can. Ven.

1507.4	8.4	Lt
13.3	8.4	Lt
57.7	8.1	L
85.9	8.9	M

135576
θ Apodis

1523.8	6.1	δ
24.5	6.2	δ
36.5	6.3	δ
38.5	6.3	δ
40.6	6.2	δ
42.7	6.4	δ
45.7	6.3	δ
48.5	6.3	δ
49.6	6.2	δ

140959
R Centauri

1524.5	6.7	δ
27.7	6.5	δ
36.5	6.6	δ
49.7	7.5	± δ

141567
U Urs. Min.

1513.3	9.1	Lt

142584
R Camelop.

1507.5	9.0	Lt
13.3	8.9	Lt
16.3	8.8	Lt
20.5	8.8	Lt
69.6	8.4	Wh

142539
V Bootis

1513.4	9.3	Lt
49.2	7.9	L
85.9	8.1	M

143227
R Bootis

1503.3	7.3	Vo
07.3	7.7	Vo
07.4	7.6	Lt
13.3	8.2	Lt
57.7	10.3	L

153378
S Urs. Min.

1567.5	9.1	V
69.6	9.0	Wh
70.6	8.8	Bg
79.5	9.3	V
92.5	8.1	V

VARIABLE STAR OBSERVATIONS, Dec.-Jan., 1917-18—Continued.

154428
R Coronae

J.D. 242	Est.	Obs.
1517.3	12.1	Lt
20.3	<11.4	L
25.2	<11.4	L
28.3	11.1	Lt
34.2	10.8	L
35.2	10.5	L
36.2	10.5	L
49.2	10.4	L
49.2	10.0	Pe
50.2	10.1	Pe
52.2	10.2	L
57.7	10.8	L
71.7	11.1	L

154536
X Coronae

1513.3	9.7	Lt
17.3	9.7	Lt
28.3	9.9	Lt

154639
V Coronae

1513.4	9.3	Lt
20.3	8.9	Lt

154648
ST Herculis

1520.3	7.8	Lt

155847
X Herculis

1503.3	6.9	Lt
07.4	7.2	Lt
13.3	7.2	Lt
16.3	7.2	Lt
20.3	7.2	Lt
92.5	7.1	Nt

160150
RR Herculis

1520.3	8.9	Lt

160325
SX Herculis

1513.3	8.7	Lt

161138
S Coronae

1574.5	8.5	Y

162119
U Herculis

1550.2	9.8	Pe

162542
g Herculis

1503.3	5.0	Lt
07.3	4.7	Lt
13.3	4.7	Lt
16.3	4.8	Lt
20.3	4.8	Lt
29.3	5.1	Lt

163172
R Urs. Min.

J.D. 242	Est.	Obs.
1513.3	9.6	Lt
20.3	9.7	Lt
69.6	9.6	Wh
70.5	10.2	De

163137
W Herculis

1507.4	8.1	Lt
13.3	8.4	Lt
20.3	8.4	Lt
65.5	9.8	M
70.5	10.8	Y

163266
R Draconis

1569.5	12.3	Y

164055
S Draconis

1507.3	9.1	Vo
13.3	9.2	Lt
16.3	9.2	Vo

164715
S Herculis

1507.4	9.3	Lt
13.3	9.3	Lt

165631
RV Herculis

1517.3	11.2	Lt
28.3	10.5	Lt
39.3	10.5	Pe
47.3	10.7	Pe
49.3	10.8	Pe
52.4	10.8	Pe
65.5	11.4	De
70.5	11.4	De

171723
RS Herculis

1550.2	<12.2	Pe
65.5	<12.0	De

173457
TY Draconis

1538.3	9.7	Pe
41.3	9.8	Pe
47.3	9.8	Pe
49.3	9.8	Pe
50.3	9.8	Pe
52.4	9.7	Pe

175458
T Draconis

1572.6	9.4	Bg

175519
RY Herculis

1520.3	9.4	Lt
41.3	9.4	Pe
47.3	9.5	Pe
49.3	9.4	Pe

180565
W Draconis

J.D. 242	Est.	Obs.
1569.6	<11.8	Wh

180531
T Herculis

1513.3	10.0	Lt
20.3	9.4	Lt
47.3	7.6	Pe
49.3	8.0	Pe
50.3	8.2	Pe
65.5	8.2	M
65.6	7.7	Hu

181031
TV Herculis

1525.2	10.1	L
34.2	10.3	L
52.3	10.3	L
68.3	10.8	L
71.2	10.9	L

181136
W Lyrae

1507.3	7.8	Vo
07.5	8.0	Lt
13.3	8.2	Vo
13.3	8.7	Lt
16.3	8.2	Vo
20.3	8.4	Vo
65.5	11.2	M
65.6	11.2	Wh
69.5	11.9	Y
71.6	12.3	Bg

182224
SV Herculis

1520.3	10.0	Lt
65.5	11.9	De

183225
RZ Herculis

1570.5	<12.6	Y

183308
X Ophiuchi

1503.3	7.8	Vo
07.3	7.9	Vo
13.3	7.9	Lt
16.3	8.0	Vo
20.3	7.9	Vo
34.2	8.4	L
52.2	8.5	L

184134
RY Lyrae

1565.6	9.8	Wh

184205
R Scuti

1503.3	6.6	Lt
03.3	7.0	Vo
04.3	6.4	Lt
04.3	6.9	Vo
07.3	6.2	Vo

R Scuti

J.D. 242	Est.	Obs.
07.5	6.1	Lt
08.4	6.1	Lt
13.3	6.0	Lt
16.3	5.9	Lt
17.3	5.9	Lt
18.5	5.9	δ
20.3	5.9	Lt
20.3	5.8	L
20.3	5.7	Vo
21.4	5.9	Lt
22.3	5.9	Lt
23.6	5.5	δ
24.5	5.8	δ
25.2	5.7	L
27.3	5.8	Lt
28.3	5.8	Lt
29.3	5.8	Lt
34.2	5.7	L
36.5	5.7	δ
38.5	5.8	δ
42.5	5.7	δ
43.2	5.7	L
52.2	5.4	Be
52.2	5.2	L
65.5	5.2	Pi
71.2	5.2	L

185243
R Lyrae

1503.3	4.2	Lt
07.3	4.1	Lt
13.4	4.2	Lt
16.3	4.2	Lt
20.3	4.2	Lt

185905
V Aquilae

1518.5	6.9	δ

190108
R Aquilae

1534.3	<11.1	L
36.2	11.5	L
52.2	11.6	L
77.4	11.3	B

190967
U Draconis

1565.6	11.0	Hu

191033
RY Sagittarii

1518.5	9.0	δ
22.6	8.9	δ
36.2	9.7	L
45.6	9.5	δ
49.6	9.4	δ

191017
T Sagittarii

J.D. 242	Est.	Obs.
1518.5	11.7	δ
35.6	11.5	L
45.6	10.9	δ
48.6	10.9	δ

191019
R Sagittarii

1518.5	12.3	δ
38.5	11.6	δ
45.6	10.8	δ
49.6	10.6	δ

191319
S Sagittari

1518.5	10.8	δ
45.6	11.2	δ
49.6	11.3	δ

191637
U Lyrae

1570.5	10.2	De

192745
AF Cygni

1507.4	7.4	Lt
16.5	7.4	Lt
20.3	7.6	Lt

193449
R Cygni

1597.4	8.7	Lt
13.3	8.6	Lt
17.3	8.8	Lt
29.3	9.1	Lt
38.3	9.5	Pe
41.3	9.7	Pe
47.3	9.8	Pe
49.3	9.8	Pe
52.3	9.8	Pe
65.6	9.1	Hu
65.8	9.5	M
70.5	9.0	De
70.6	9.4	Wh
70.7	10.1	Bg
71.8	11.3	By
78.5	<11.5	B
79.5	10.5	V
92.5	11.0	V

193509
RV Aquilae

1565.6	<12.2	Wh

193732
TT Cygni

1536.3	7.9	L
53.3	7.8	L
65.6	7.2	Hu
71.6	8.0	Bg

VARIABLE STAR OBSERVATIONS, Dec.-Jan., 1917-18—Continued

194048
RT Cygni

J.D. 242	Est.	Obs.
1507.4	10.0	Lt
13.3	9.5	Lt
17.3	9.5	Lt
20.4	9.3	Lt
65.5	8.4	M
65.6	8.0	Hu
70.5	8.0	De
70.6	8.3	Wh
70.7	8.4	Bg
70.8	8.0	By
73.5	8.5	V
78.5	8.1	B
92.5	8.6	V

194348
TU Cygni

J.D. 242	Est.	Obs.
1517.3	10.8	Lt
65.5	<11.6	M
65.6	13.0	Hu
70.5	<12.7	De
70.7	<10.8	Bg
75.5	<10.9	V

194604
X Aquilae

J.D. 242	Est.	Obs.
1565.5	<11.6	Pi
65.6	<12.2	Wh

194632
χ Cygni

J.D. 242	Est.	Obs.
1541.3	<11.7	Pe
49.3	12.5	Pe
52,4	12.4	Pe
65.5	<12.6	Hu
79.5	10.4	V
85.6	9.7	Hu

194700
η Aquilae

J.D. 242	Est.	Obs.
1514.3	4.0	Be
16.2	3.7	Be
20.3	4.1	Be
25.2	4.1	Be
28.2	4.5	Be
35.2	4.2	L
35.2	4.2	Be
36.2	4.1	L
36.2	4.4	Be
37.2	3.7	L
43.2	4.0	L
49.2	4.6	Be
49.2	4.2	L
51.2	3.6	Be
52.2	3.8	Be
52.3	3.7	L
53.3	3.8	L
55.2	4.1	Be
55.2	4.1	L
57.2	4.2	Be
65.2	3.7	Be

η Aquilae

J.D. 242	Est.	Obs.
1566.2	3.6	Be
68.2	3.9	Be
71.2	4.2	L

195116
S Sagittae

J.D. 242	Est.	Obs.
1514.2	5.1	Be
15.2	5.5	Be
16.2	5.3	Be
17.3	5.4	Be
20.3	5.7	Be
25.2	5.8	Be
35.2	5.9	L
35.2	6.1	Be
36.2	5.7	L
36.2	5.6	Be
37.2	5.9	L
43.2	5.6	L
49.2	5.2	Be
49.2	5.3	L
51.2	6.1	Be
52.2	5.8	Be
52.3	5.9	L
53.3	5.9	L
55.2	5.4	Be
55.2	5.6	L
57.2	5.5	Be
65.2	5.5	Be
66 2	5.4	Be
66.3	5.2	L
68.2	6.0	Be
71.2	5.6	L

195849
Z Cygni

J.D. 242	Est.	Obs.
1565.5	<11.6	M
70.6	12.4	Me
70.6	<12.1	Wh
78.6	<10.6	Al
79.5	<11.1	V

200212
SY Aquilae

J.D. 242	Est.	Obs.
1565.5	<11.9	Bi
65.6	<11.8	Wh

200357
S Cygni

J.D. 242	Est.	Obs.
1565.5	<10.0	M
70.6	<12.2	Wh
74.5	<12.4	De

200514
R Capricorni

J.D. 242	Est.	Obs.
1518.5	12.6	δ
45.6	12.7	δ
49.6	12.7	δ

200647
SV Cygni

J.D. 242	Est.	Obs.
1565.5	9.0	M
70.6	8.7	Hu
78.4	8.7	B

200715a
S Aquilae

J.D. 242	Est.	Obs.
1535.2	10.8	L
52.3	9.4	L
65.5	9.4	Pi
72.6	9.6	Bg
73.5	9.5	De

200715b
RW Aquilae

J.D. 242	Est.	Obs.
1565.5	9.2	Pi
72.6	9.0	Bg
73.5	9.2	De

200822
W Capricorni

J.D. 242	Est.	Obs.
1518.6	<12.5	δ
70.6	<11.2	Me

200916
R Sagittae

J.D. 242	Est.	Obs.
1513.3	9.6	Lt
72.5	8.7	Bg
73.5	9.0	De

200938
RS Cygni

J.D. 242	Est.	Obs.
1507.4	8.9	Lt
13.3	8.9	Lt
36.3	9.0	L
52.2	9.1	L
65.6	8.5	M
70.6	8.9	Wh

201008
R Delphini

J.D. 242	Est.	Obs.
1507.5	9.0	Lt
13.3	8.4	Lt
16.3	8.4	Lt
20.3	8.2	Lt
72.6	9.5	Wh
72.6	9.3	Bg
75.5	9.4	B
77.8	10.0	B

201130
SX Cygni

J.D. 242	Est.	Obs.
1565.5	12.4	De
78.5	12.2	B

201121
RT Capricorni

J.D. 242	Est.	Obs.
1518.6	7.3	δ
23.6	7.0	δ
35.2	7.8	L
38.6	7.4	δ
49.6	7.4	δ
52.2	8.1	L
70.6	8.0	Me

201647
U Cygni

J.D. 242	Est.	Obs.
1565.5	10.4	M
70.6	10.2	Wh
70.7	9.7	Bg

202539
RW Cygni

J.D. 242	Est.	Obs.
1536.3	8.6	L
53.2	8.4	L
65.6	8.3	M
70.6	7.5	Wh
71.6	8.2	Bg
73.7	8.6	Me

202622
RU Capricorni

J.D. 242	Est.	Obs.
1518.6	11.2	δ
23.6	11.1	δ
38.6	11.7	δ
49.6	11.9	δ

202732
AD Cygni

J.D. 242	Est.	Obs.
1513.3	9.3	Lt

202732a
AI Cygni

J.D. 242	Est.	Obs.
1513.3	9.2	L

202817
Z Delphini

J.D. 242	Est.	Obs.
1572.6	11.5	Wh

202946
SZ Cygni

J.D. 242	Est.	Obs.
1536.3	9.4	L
37.3	9.4	L
65.6	9.2	M
68.3	9.5	L
70.6	9.6	Hu
70.6	9.7	Wh
71.2	9.7	L
87.6	10.1	B

202954
ST Cygni

J.D. 242	Est.	Obs.
1569.6	12.5	Y
70.6	<12.6	Hu
74.5	<12.1	De

203611
Y Delphini

J.D. 242	Est.	Obs.
1572.6	<12.1	Wh

203816
S Delphini

J.D. 242	Est.	Obs.
1575.5	11.3	B

203847
V Cygni

J.D. 242	Est.	Obs.
1570.7	9.6	Bg

203905
Y Aquarii

J.D. 242	Est.	Obs.
1550.3	<12.2	Pe

204016
T Delphini

J.D. 242	Est.	Obs.
1572.6	<12.0	Wh

204017
U Delphini

J.D. 242	Est.	Obs.
1503.3	6.4	Lt
07.3	6.4	Lt
13.4	6.4	Lt
14.3	6.6	Be
16.2	6.7	Be
16.3	6.5	Lt
10.3	6.4	Lt
36.2	6.7	Be
37.3	6.6	L

204104
W Aquarii

J.D. 242	Est.	Obs.
1550.3	<13.0	Pe

204318
V Delphini

J.D. 242	Est.	Obs.
1572.6	<11.7	Wh
77.5	<12.5	B

204405
T Aquarii

J.D. 242	Est.	Obs.
1550.3	9.2	Pe
65.5	7.8	De
73.6	7.6	Bg

205017
X Delphini

J.D. 242	Est.	Obs.
1572.6	8.8	Wh
75.5	8 8	B

205923
R Vulpeculae

J.D. 242	Est.	Obs.
1507.5	8.6	Lt
13.3	8.4	Lt
17.3	8.2	Lt
20.5	8.2	Lt
70.6	11.0	Hu
71.7	<10.6	Bg

210124
V Capricorni

J.D. 242	Est.	Obs.
1518.6	<13.0	δ
23.6	<13.0	δ

210129
TW Cygni

J.D. 242	Est.	Obs.
1569.6	<13.0	Y

210116
RS Capricorni

J.D. 242	Est.	Obs.
1518.6	8.0	δ
23.6	8.1	δ
43.2	8.2	L
45.6	8.0	δ
52.2	8.5	L
77.8	8.5	By

210221
X Capricorni

J.D. 242	Est.	Obs.
1518.6	12,3	δ
23.6	12.1	δ
38.6	12.2	δ
49.6	12.4	δ

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210516
Z Capricorni

J.D. 242	Est.	Obs.
1518.6	10.6	δ
23.6	11.7	δ
38.6	13.2	δ

210868
T Cephei

1503.3	8.2	Vo
07.3	8.0	Vo
13.3	8.1	Lt
16.3	8.1	Vo
20.5	8.1	Lt
22.3	8.1	Vo
35.3	7.9	L
55.2	6.8	L
69.6	6.5	Wh
70.6	7.0	Hu
70.7	6.9	Bg
77.8	6.7	By

211615
T Capricorni

1518.6	11.6	δ
23.6	11.8	δ
38.6	12.3	δ
49.6	12.7	δ
50.6	12.7	δ

211614
X Pegasi

1569.6	10.9	V

213244
W Cygni

1503.3	6.7	Lt
07.3	6.7	Lt
13.4	6.7	Lt
16.3	6.7	Lt
20.3	6.8	Lt
24.6	5.8	L
41.3	6.1	Pe
49.3	6.2	Pe
49.3	5.5	L
65.3	5.5	L

213678
S Cephei

1565.5	11.7	De
69.6	11.8	Wh
70.6	10.9	Hu
88.5	11.9	B

213753
RU Cygni

1516.3	8.0	Lt
65.6	8.6	M
68.3	7.7	L
70.7	7.6	Bg
73.5	8.2	Pi

213843
SS Cygni

J.D. 242	Est.	Obs.
1507.3<	9.6	Vo
16.3<	9.0	Vo
17.3	11.6	Lt
20.3<	9.6	Vo
22.3	8.6	Vo
22.5	8.4	Lt
23.3	8.4	Lt
24.5	8.2	L
27.4	8.4	Lt
35.3	9.5	L
36.3	9.7	L
41.3	11.3	Pe
49.3	11.8	Pe
49.3	11.6	Pe
49.3	11.6	L
52.4	11.4	Pe
57.8	11.1	By
65.2	12.0	L
65.5<	10.4	M
65.5	11.6	Pi
65.6	11.7	Wh
67.5<	11.3	V
68.3	12.0	L
68.6	11.5	Me
69.5	11.5	Y
69.6	11.4	Me
70.5	11.6	De
70.6	11.4	Wh
70.6	11.9	Hu
70.6	11.4	Me
71.2	11.8	L
71.7	11.2	Me
72.6	9.1	Me
73.5	8.7	B
73.6	8.5	Pi
73.6	9.0	Me
74.5	8.6	B
74.5	8.5	Pi
74.7	8.9	Mu
75.5	8.9	B
75.6	9.0	Me
75.7	9.5	Bg
77.4	9.8	B
77.7	9.5	Me
78.4	10.2	B
81.7	10.7	Me
82.6	11.2	Me
85.5	11.9	B
85.6	12.0	Hu
86.7	11.3	Me
87.5	11.5	B
88.5	11.9	B
90.4	11.8	B
92.5<	10.7	V
92.5	11.2	Sp
93.6	11.5	Wh

213937
RV Cygni

J.D. 242	Est.	Obs.
1536.3	7.1	L
65.5	7.7	De
65.6	8.2	M
68.3	6.6	L
70.6	7.9	Hu
74.5	8.3	Pi
75.6	8.2	Bg
78.5	7.5	B
90.5	7.5	B

214024
RR Pegasi

1565.5	10.5	De
88.5	11.9	B

215605
V Pegasi

1570.8	9.3	By
73.6	10.4	V
77.8	9.5	By

215717
U Aquarii

1518.6<	12.9	δ
23.6<	13.0	δ
38.5<	15.0	δ

220412
T Pegasi

1578.5	12.4	B

220613
Y Pegasi

1565.5	12.2	De

220714
RS Pegasi

1565.5<	12.5	De

221321
X Aquarii

1518.6	12.0	δ
21.6	12.0	δ
23.7	12.1	δ
38.6	13.2	δ
49.6	13.6	δ

221722
RT Aquarii

1521.6	11.3	δ
23.7	11.2	δ
38.6	12.1	δ
49.6	12.3	δ

222439
S Lacertae

1570.6	11.8	Wh
77.5	12.1	B

225120
S Aquarii

J.D. 242	Est.	Obs.
1521.6	13.2	δ
23.7	13.0	δ
68.6	13.8	Me
70.5	12.0	Y

225914
RW Pegasi

1513.3	10.7	Lt
20.5	10.8	Lt
69.5	12.5	Y
70.6<	12.1	Wh
72.5<	12.3	De
77.5<	12.4	B

230110
R Pegasi

1517.3	11.6	Lt
38.3	10.6	Pe
39.3	10.5	Pe
41.3	10.3	Pe
47.3	10.3	Pe
49.3	10.3	Pe
52.4	10.2	Pe
66.6	9.3	Y
68.7	10.0	Me
70.6	9.0	Hu
70.6	9.2	Wh
71.7	9.4	Bg
71.8	9.2	By
74.7	8.7	Mu
77.8	8.8	By
85.6	7.5	Hu
92.5	8.2	Sp

230759
V Cassiop.

1503.3	8.5	Vo
07.3	8.3	Vo
07.5	8.3	Lt
16.3	8.8	Lt
16.3	8.7	Vo
20.3	8.8	Vo
70.6	10.9	Hu
71.7	11.3	Bg
73.6<	11.2	V
73.7<	11.4	M
78.7	12.0	Wh

231425
W Pegasi

1565.5	12.4	De
72.5	12.2	De

231508
S Pegasi

1549.5	10.9	Pe
70.6	9.3	Wh
71.7	10.0	Me
85.5	9.6	B

231917
RU Aquarii

J.D. 242	Est.	Obs.
1521.6	9.6	δ
23.7	9.5	δ
38.6	8.9	δ

233335
ST Androm.

1570.6	10.0	Hu
71.7	10.7	Bg
77.6	10.4	B
92.5	10.5	Sp

233451
SV Cassiop.

1513.4	7.3	Lt

233815
R Aquarii

1507.4	6.5	Lt
13.3	6.3	Lt
16.4	6.4	Lt
20.4	6.6	Lt
21.7	6.2	δ
23.7	6.0	δ
38.6	6.7	δ
49.2	6.8	L
49.6	7.0	δ
70.8	8.4	By
71.2	8.0	L

234716
Z Aquarii

1513.4	8.5	Lt
20.5	8.6	Lt
21.7	8.7	δ
23.7	8.5	δ
38.6	9.2	δ
49.6	9.3	δ
65.6	9.5	Wh

235350
R Cassiop.

1517.3	12.8	Lt

235715
W Ceti

1521.7<	14.0	δ
23.7<	14.0	δ
36.7	14.5	δ
50.6	14.5	δ

235939
SV Androm.

1565.6<	12.7	De
66.6<	13.0	Y

No. of Observations 1169; No. of Stars Observed 243; No. of Observers 20.

now being observed by a member of the Association and these observations will add greatly to the value of our records. Mr. Dawson made sixty-two observations of the Algol variable *004872* V Toucanae which do not appear in this report. His observations of the tenth magnitude comparison star in the field of the Variable *191033* RY Sagittarii would indicate that the star may be a variable.

Mr. Lacchini's report for last month was received too late for publication and appears herewith. Mr. Lacchini contributes to the records of the Association his published observations of the variable *021403 o* Ceti from July 1914 to March 1917 together with the plotted light curve, and the thanks of the Association are due him for his valuable contribution to our records.

Rev. T. C. H. Bouton and Mr. W. P. Meeker are located for the winter at St. Petersburg and Miami, Florida, respectively. Mr. Meeker has his 4″ refractor mounted on his house, and contributes this month a very creditable set of observations.

Miss Leah B. Allen of the Whitin Observatory, Wellesley College, has joined the ranks of active observers. Miss Allen's observations appear under the abbreviation "Al."

The Hagen chart of the Variable 032335 R Persei is defective and should be discarded by those who use this chart. We hope in the near future to circulate photographic charts approved by the Harvard College Observatory in place of the charts now in use which have served a useful purpose but are not altogether free from errors.

Notices of the meeting at Cambridge November 10 have appeared in "Science," 'The Guide to Nature," and "The Monthly Evening Sky Map." These have brought the secretary many letters of inquiry regarding the work of the Association from interested parties and clearly indicate that there are still many telescopists willing to coöperate with us who are unaware of the nature and scope of our activities. It is hoped that our members will use every endeavor to interest others in what we are doing and secure new recruits.

The Secretary is indebted to Mr. Leon Campbell for a list of calculated dates of Maxima and Minima of many of the Variables that we are observing for the year 1918. As this is matter of interest to all our members these facts will appear in the reports. The following dates are to be noted for the month of February:—

Day	Variable	Max. or Min.	Day	Variable	Max. or Min.
Feb. 4	054920 U Orionis	Min.	Feb. 12	160210 U Serpentis	Max.
5	001755 T Cassiopeiae	Min.	15	063558 S Lyncis	Min.
5	162807 SS Herculis	Min.	24	004958 W Cassiopeiae	Min.
7	193509 RV Aquilae	Max.	27	103769 R Ursae Majoris	Min.
8	195849 Z Cygni	Max.			

The following members contributed to this report: Miss Allen, Benini, Bolfing, Bouton, Bryan, Dawson, Delmhorst, De Perrot, Hunter, Lacchini, Luyten, McAteer, Meeker, Mundt, Nolte, D. B. Pickering, Spinney, Vrooman, Whitehorn, Miss Young.

WILLIAM TYLER OLCOTT,
Secretary.

Norwich, Conn.
January 10, 1918.

***o* Ceti and α Orionis.**—From October 31 to November 21, 1917 inclusive *every* night was clear at North Scituate, R. I., and *o* Ceti and α Orionis were observed on each night. *o* Ceti was *steady* at 0.1 of a magnitude fainter than α Piscium and α Orionis was *steady* at 0.25 of a magnitude brighter than α Tauri, Aldebaran.

FRANK E. SEAGRAVE.

Boston, Nov. 22, 1917.

COMMUNICATIONS.

The Proposed Adoption of the Civil Date by Astronomers.—Neither tradition nor mere convenience should stand in the way of uniformity of practice as between different occupations, when safety, as of persons or property at sea, or simplicity and economy in the practical affairs of applied science, are involved.

There appear to be only two important objections to the proposed change. The *first* is the danger of real uncertainty of one day in the date of observations made in the hours from midnight to noon. For such it would be essential—through a sufficient interval of years—that the date be specified as astronomical, in accordance with the practice up to the present time, or civil. Noting the hour, sidereal or mean time, while desirable and in general necessary, in the record, would not be sufficient; neither would noting the day of the week, since there appears to be no general convention amongst astronomers as to which of the two days in the week, in any particular case of an astronomical date, is to be put down for those hours. Therefore, if the change be made in the ephemerides, all observers should be warned and requested to note whether the date is astronomical or civil, and to continue this practice for a term of several years until the new convention becomes established beyond question.

The *second* objection arises in connection with publishing and printing the results of a series of observations begun before midnight and going on into the morning hours. Here the adoption of the civil date would cause considerable annoyance to one referring to tables of such results; for the earlier observations of a given night would appear under a certain date, while the later succession of observations, although in continuity with the former, would appear under the next date later. This annoyance would be perpetual. Here it would seem necessary to print a second item of some sort, forming a second column of the table, to define the dates as to morning and evening. The day and hour sidereal or mean time, preferably the latter, would suffice; or the designations A. M. and P. M., or only the letters A and P, also would suffice. The device might be adopted of printing the dates of A. M. observations in a different type from that of the P. M. observations, thus avoiding the extra column. Such devices, however, are apt to offend the eye and should not be carried too far. It would seem to be in the best form to print the double date, as 1918, January 15-16, for a series of observations made through the night following noon of January 15. Indeed, if the change be made, it would seem desirable to print all of the dates in tables of observed astronomical data in this form for the sake of uniformity.

The writer is in favor of adopting the civil date.

ALBERT S. FLINT.

Washburn Observatory.
Madison, Wis.

The Civil and the Astronomical Day.—In reply to a note published in POPULAR ASTRONOMY, December 1917, let me say that I consider it best to have the Astronomical Day set back twelve hours and have it begin at midnight instead of at noon. Personally I never could see the reason for having the Astronomical and Civil Day beginning at different times.

I hope to see this important change made in the near future.

OSCAR L. DUSTHEIMER.
Professor of Astronomy, Baldwin-Wallace College

Berea, Ohio.

Venus Visible near Conjunction.—In POPULAR ASTRONOMY, June, 1915, page 388, Mr. Wilfrid Griffin of Pittsfield, Mass., reported his early observation of a new moon, and in later issues there were one or two other communications on this subject. May I call attention to the unusually favorable opportunity coming soon to see one of the planets near the time of conjunction with the sun? Venus is to be in inferior conjunction on February 10, and will be nearly 8° north of the sun; therefore, when in the same right ascension as the sun, Venus will rise about half an hour before it and set about half an hour after it. Although not nearly so bright as at the beginning of January, yet Venus will be still very brilliant, and should be seen within two or three days, at most, of the date of conjunction. Careful observers if favored with excellent weather, may perhaps see the planet in the east before sunrise, and in the west after sunset on the same day, as I was able to do on February 14, 1902, when the circumstances were much the same as this year.

In the southern hemisphere the conjunction of September, 1919, will offer an even better chance than the present one in the northern hemisphere. Each eight years the opportunities are repeated with only slight change, but the February conjunctions are steadily becoming less favorable, as the date becomes earlier little by little.

HERBERT C. HUNTER.

East Falls Church, Va.
January 8, 1918.

GENERAL NOTES.

William McKnight Ritter, the astronomer, formerly connected with the Nautical Almanac office and there closely associated with the work of George W. Hill, died on November 6, at his home in Pottsgrove, Pa., at the age of seventy-one. In his earlier astronomical career he became, through Professor Watson, of Ann Arbor, greatly interested in the computation of orbits for minor planets, and during the later years he devoted special study to the problem of the general perturbations of these planets. (*Science*, Dec. 21, 1917.)

Second Lieutenant F. Entwistle, second assistant at the Observatory, Cambridge, England, aged twenty-one years, was killed while leading his platoon during one of the recent advances in France.

Mr. Hartley, first assistant, was killed on the *Vanguard* on July 9. The double tragedy exhausts the staff of the observatory, as distinct from the Solar Physics Observatory, except for the director. (*Science*, Dec. 21, 1917.)

Professor Clement Henry McLeod, professor of astronomy, surveying and geodesy, McGill University, in charge of the observatory, died on December 26, aged sixty-six years. (*Science*, Jan. 4, 1918.)

Mr. T. F. Claxton, director of the Royal Observatory, Hong-Kong, informs *Nature* that, in view of the world situation, it has been decided to discontinue sending the publications of the Observatory to the United Kingdom, Europe and India during the war. (*Science*, Jan. 4, 1918.)

Professor G. H. Scott, for fifteen years professor of mathematics and astronomy at Yankton College, Yankton, South Dakota, has resigned to become principal of Benzonia Academy, Benzonia, Michigan (*Science*, Jan. 4, 1918.)

Companion to the Observatory.—As usual the English astronomical periodical *The Observatory* has issued its handbook, the "Companion to the Observatory" for the present year. This contains tables of sunrise and sunset for every seventh day, with other data concerning the sun; tables of the moon for every day; the list of eclipses; occultations visible at Greenwich; phenomena of the planets and their satellites; ephemeris for physical observations of the sun; and data concerning meteor showers, variable stars, double stars and clusters. The "Companion" is very useful to amateur astronomers.

Notes from Yerkes Observatory.

Dr. Oliver J. Lee, who has been in charge of the instruction at the Navigation School of the U. S. Shipping Board in Chicago since July, 1917, has been given leave of absence until June 30, 1918 to continue that work. In a private letter just received Mr. Lee says that he has turned out four classes of navigators and has about 40 members in the fifth session at present.

Professor Edison Pettit, of Washburn College, Topeka, Kansas, began work at the observatory January 1, 1918. He will make the observations of the sun with the spectroheliograph for the next six months, as he did during the summer of 1917, and will also assist in work in the Department of Stellar Parallax, which is now in charge of Professor Van Biesbroeck.

Miss Hannah B. Steele, who has been at the observatory for the past sixteen months, is continuing her studies during the next two Quarters at the University of Chicago.

Miss Evelyn W. Wickham, computer in spectroscopy, received the degree of M. S. at the December convocation of the University of Chicago.

Hours of Observation with the 40-Inch Telescope.

Month 1917		Mean for 15 years	Gain 1917
Jan.	194	133½	60½
Feb.	163½	132	31½
Mar.	134	131	3
Apr.	117	124	— 7
May	142	120	22
June	112	128	— 16
July	177	152	25
Aug.	194½	156	38½
Sept.	170½	158	12½
Oct.	69½	175	—105½
Nov.	158½	147	11½
Dec.	151	142	9
Total for the year	1783½ hours	1698½ hours	85 hours

Rainfall at Yerkes Observatory.

Month	1917		Mean for 15 years		Gain 1917	
	Inches	Milimeters	Inches	Millimeters	Inches	Millimeters
Jan.	0.45	11	1.50	38	−1.05	−27
Feb.	0.51	13	1.19	30	−0.68	−17
Mar.	1.11	28	1.77	45	−0.66	−17
Apr.	4.01	102	2.48	63	+1.53	+39
May	4.10	104	3.91	99	+0.19	+ 5
June	4.36	111	3.16	80	+1.20	+31
July	2.65	67	3.48	88	−0.83	−21
Aug.	0.53	13	4.01	102	−3.48	−89
Sept.	4.49	115	3.72	96	+0.77	+19
Oct.	4.94	125	2.43	62	+2.51	+63
Nov.	0.41	10	1.64	42	−1.23	−32
Dec.	0.27	7	1.38	35	−1.11	−28
Total for the year	27.83	706	30.67	780	−2.84	−74

The above data for the number of hours of observation with the 40-inch telescope show that the excellent record of 1916 was maintained, almost without exception, up to the first of October, at which date there had been an accumulation of 170 hours or about 14 per cent above the normal for 15 years. This was in part due to the excellent conditions in July and especially in August, which were closely associated with the drouth at that time. A large amount of clear sky in January and February was also connected with the deficit in precipitation during those months. The conditions in October were exceedingly bad, yielding over 100 hours less than normally. November and December were slightly better than the normal, so that on the whole the year shows a gain of 85 hours over the normal. There were during the year some nights of very fine seeing.

Resumé of Sunspot Observations at Mount Holyoke College, 1917.

Month	No. of Obs.	North of equator		South of equator		Av. No. at Each Obs.	New Groups
		No. Groups	Av. Lat.	No. Groups	Av. Lat.		
			°		°		
Jan.	14	21	+17.0	10	−17.6	5.86	31
Feb.	16	14	+20.1	8	−12.3	3.94	19
Mar.	18	17	+17.0	7	−14.2	6.06	21
Apr.	14	12	+15.2	13	−17.1	5.43	25
May	15	15	+13.9	16	−16.8	6.87	29
June	5	7	+17.2	9	−13.4	7.80	12
Sept.	7	6	+15.0	8	−14.7	8.57	14
Oct.	14	12	+14.9	13	−15.5	4.71	23
Nov.	18	18	+14.0	12	−14.4	5.56	28
Dec.	10	14	+13.0	10	−13.5	7.20	20
Total	131	135		106			222

Average number at each observation 5.88
Average latitude of groups north of equator +14°.5
Average latitude of groups south of equator −14°.0

The method of observation was the same as that followed in previous years. The observation made February 24 was the only one when no spots were seen.

LOUISE F. JENKINS.

John Payson Williston Observatory.

The Sun and the Weather.—This is the title of a very interesting paper by Dr. C. G. Abbot in the November, 1917, number of *The Scientific Monthly*. Near the close of the paper, after discussing some results of an investigation by Dr. H. H. Clayton of Argentina, formerly of Blue Hill, Massachusetts, Dr. Abbot calls attention to unexpectedly large changes of temperature at certain stations on the earth, occurring from two to four days after important changes in the solar radiation had been noted. Among other conclusions he states "...and as the maximum effects of solar changes follow from one to five days after the cause, depending on the latitude of the station, it may be possible that a large proportion of weather changes will become predictable for some time in advance, if daily measurements of the solar emission shall be secured."

For this purpose it would be necessary to have stations widely scattered on the earth for the daily measurement of the solar emission. Dr. Abbot suggests that, "A bequest of half a million dollars to the Smithsonian institution would enable it to handle adequately this apparently exceedingly important problem."

Relativity.—In the *Proceedings of the National Academy of Sciences* Vol. 3 pp. 450-452, July 1917, Professor St. John of the Mount Wilson Solar Observatory gives a very brief notice of his work in search for an Einstein relativity-gravitational effect in the sun. From a study of the behavior of the lines in the nitrogen (cyanogen) bands, at wave-length 3883, at the center and limb of the sun, he concludes that "within the limits of error the measurements show no evidence of an effect of the order deduced from the equivalence relativity principle."

In the *Monthly Notices* of the Royal Astronomical Society, March 1917, it was pointed out by the Astronomer Royal of England, Sir F. W. Dyson, that the total solar eclipse of May 29, 1919, will afford an opportunity of verifying Einstein's theory of gravitation, since the sun during totality will be just north of the Hyades group of stars and several stars of magnitude 7.0 and brighter will be near enough the sun to be photographed upon large scale plates with the latter. The theoretical displacement of one of these stars is 1″.0 and thirteen of them should show displacements of more than 0″.25.

This eclipse will be visible in South America and Africa and the duration of totality is long, five minutes on the northern coast of Brazil and western coast of Africa and six minutes at St. Paul Island in the Atlantic.

Distribution of Stars in Twelve Globular Clusters.—This is the title of a paper by Francis G. Pease and Harlow Shapley in the *Astrophysical Journal*, May 1917, and reprinted as "Contributions from the Mount Wilson Solar Observatory No. 129." From counts of more than half a million star images, on a series of plates made at the principal focus of the 60-iinch reflector, it is found, that: Of the nine clusters for which fairly definite counts are available, five show elliptical form, three appear sensibly circular and one may be peculiar. The three clusters with similar density in all directions from the center are noticeably less condensed, a condition that follows naturally if the poles of their galactic planes are assumed to be approximately in the line of sight.

"The proportion of clusters with measurable elongation here found is about what should be expected on the galactic hypothesis if the inclinations are distributed at random.

"Axes of symmetry in these clusters do not appear until the arrangement of several thousand stars is analyzed. The failure previously to detect the ellipticity,

which in same cases amounts to nearly 30 per cent, must be attributed to an inflence of the brighter stars, which, in general, do not show elliptical distribution. The ellipticity appears at all distances from the center, and also for all magnitudes. after the giant red stars have been excluded."

The Color-Curve of XZ Cygni.—In *Contributions from the Mount Wilson Solar Observatory* No. 128, Martha Betz Shapley discusses the curve representing the change of color of this variable, which is of the δ Cephei type with a period of 0.466586 day. She finds, by comparing the light curves obtained from photographs taken with ordinary and isochromatic plates, that the photographic range is much greater than the photovisual range and that the color curve is very similar in form to the light curve and synchronous with it, i. e., the maxima occur at the same time in both curves.

The Distances of Globular Star Clusters.—In the *Proceedings of the National Academy of Sciences* Vol. 3, pp. 479-484, July 1917, Mr. Harlow Shapley gives a method of approximating the distances of globular star clusters. which are far beyond the limit of direct measures of parallax. This method is based on the fact that the variable stars of the "cluster-type", or short period Cepheids, in each cluster appear to have a certain definite median magnitude (average of minimum and maximum). The cluster Messier 3, in *Canes Venatici*, has over a hundred such variables with periods averaging a little over half a day. Fifty-four of these have fairly well determined light curves with a range of about 1.2 magnitudes between maxima and minima. The median magnitude for these 54 stars is 15.49 on the Mount Wilson system, with a probable error of less than a hundredth of a magnitude and an average deviation from this mean for a single star of ± 0.07.

There are great extremes of brightness among the stars of this cluster—nine or ten magnitudes at least. More than 20,000 stars fainter than these variables have been photographed at Mount Wilson and no variables of any kind found among them. It appears that the periodic light variations in this cluster are confined to a narrow interval of brightness.

The same conclusion has been reached in the case of other globular clusters. In Messier 5, in *Serpens*, 61 variables yield a median magnitude of 15.26 ± 0.01 and an average deviation for a single star of ± 0.075. In Messier 15, in *Pegasus*, 51 stars give the median magnitude 15.59, the extreme range from minima to maxima being 1.22. In the cluster ω *Centauri* 76 variables give a median magnitude of 13.57 ± 0.10. These have been divided into three sub-classes according to range of variation, but the median magnitude comes out the same within reasonable limits of error for the three sub-classes.

The inference seems quite obvious that in each cluster the variables of the Cepheid type are confined to a certain stage in the development of the stars. If this stage should be the same in all the clusters the different median magnitudes would point to different distances of the clusters and if we could determine the distance of one we could from that find the distances of all, within rather narrow limits of error as star distances go.

If we may go so far as to assume that the bright Cepheids in our own stellar system are at the same stage of development, and so of the same absolute magnitude, within as narrow a range as is indicated in the clusters, the problem becomes almost a determinate one. That *if*, however, is a big one.

The only Cepheids for which I can find measured parallaxes are SU *Cassiopeiae* and η *Aquilae*. For the first van Maanen found a parallax of $+0''.010$ and for

the second Mitchell found $+0''.006$. Adams by his spectroscopic method finds $+0''.010$ and $+0''.020$ for the two stars respectively. As these are all uncertain by somewhere about $\pm 0''.010$ we shall not be far wrong if we adopt the means of the parallax determined by the trigonometric and spectroscopic methods, viz., $+0''.010$ and $+0''.013$.

On the assumption that the absolute magnitudes of two stars are the same we have

$$\frac{\pi_2}{\pi_1} = \frac{d_1}{d_2} = \frac{\sqrt{b_2}}{\sqrt{b_1}} = \frac{(2.512)^{\frac{m_1 - m_0}{2}}}{(2.512)^{\frac{m_2 - m_0}{2}}} = (2.512)^{\frac{m_1 - m_2}{2}}, \qquad (1)$$

$$\log \pi_2 = \log \pi_1 - 0.2\,(m_2 - m_1), \qquad (2)$$

where π, d, b, and m are respectively the parallax, distance, apparent brightness, and magnitude of a star, the subscripts designating which star. Applying formula (2) and using the median magnitudes of SU *Cassiopeiae* (6.10) and η *Aquilae* (4.22) as m_1 and the parallaxes given above ($+0''.010$ and $+0''.013$) as π_1, I find for the clusters M3, M5, M15 and ω *Centauri* the parallaxes π_2 given in the following table in columns 4 and 5. In the last column Mr. Shapley's estimates of the parallaxes of the clusters are given on the assumption that the absolute median magnitudes of the Cepheid variables in the clusters are between -0.5 and $+1.5$.

	Median Magnitude	π_1	π_2 SU Cass.	π_2 η Aq.	π_2 Shapley
		"	"	"	"
SU Cassiop.	6.10	0.010			
η Aquilae	4.22	0.013			Between
M3	15.50		0.00013	0.00007	0.00006 and 0.00016
M5	15.26		0.00015	0.00008	0.00007 and 0.00018
M15	15.59		0.00013	0.00007	0.00006 and 0.00015
ω Centauri	13.60		0.00032	0.00017	0.00015 and 0.00038

It will be seen that the parallaxes of the clusters referred to SU *Cassiopeiae* and η *Aquilae* come within the range adopted by Shapley.

Gravitational Repulsion is the title of a paper published as No. 5 of Volume XXIII of the *Transactions of the Academy of Science of St. Louis* by Dr. Francis E. Nipher. This presents a new idea, as gravitation has hitherto been regarded only as an attraction and not a repulsion. The well-known statement of the law by Newton is in terms of attraction only. Through a long series of experiments Dr. Nipher shows that the attraction of two spheres for each other varies according to the electrical charges upon them. Moreover such a condition can be brought about by changing the electrical charges so as to cause the bodies to repel each other. More elaborate apparatus would be needed to obtain precise quantitative results, but the qualitative results are clearly demonstrated. The author therefore suggests a term to be added to Newton's formula. This term in the case of large masses such as the planets would be relatively very small and consequently have practically no effect upon their motions.

Celestial Objects for Common Telescopes.—By Rev. T. W. Webb, M. A., F. R. A. S. Sixth edition; thoroughly revised by Rev. T. E. Espin, M. A., F. R. A. S. In two volumes with illustrations. Longmans, Green & Co. 1917. Price $2.50 per volume.

The very fact that this work has run to the sixth edition proves its merit. It

should be in the hands of every amateur who wishes to explore the heavens with a telescope of moderate size. Mr. Webb used refracting telescopes of 3-1/7 and 5-½ inches and reflectors of 8 and 9 inches aperture, and so his descriptions are of objects as they may be seen by the possessors of small telescopes. These descriptions are supplemented by notes, culled from many sources, where the observers had the use of larger instruments. Rev. T. E. Espin, in preparing the sixth edition, has obtained the aid of a number of astronomers, experts in their own particular lines of study. As a rule the data are reliable and brought well up to date. The illustrations are better than in the former editions but are not as well printed as they might have been, in the copy which has come to our hands.

THE ASTRONOMER.

Copenhagen reports that Encke's Comet has reappeared.

He can route the sun Arcturus,
He can map Orion's bands;
He can lure us and assure us,
For we know he understands.
Scarcely anything to speak of
'Scapes his trusty spectroscope;
But a hairy, scary streak of
Gas defies his deepest dope.
A comet always gets him,
Always frets him and upsets him;
For he can't make head or tail of it at all.

He can figure mass and motion,
And can plumb the depths of space;
He can sail the cosmic ocean
In the ships upon its face.
Though a thousand light-years from it
He can analyze a star;
But the coming of a comet
Gives his intellect a jar.
A comet gets him hazy,
More than mazy, nearly crazy;
For he can't make head or tail of it at all.

As a seed of the pomegranate,
As a grain of golden sand,
He can weigh the winging planet
In the hollow of his hand.
He can heft the bulk of Venus,
And can tell you to a pound
How the difference between us—
Earth and Venus—may be found.
But a comet has him guessing,
Effervescing, and confessing
That he can't make head or tail of it at all.

B. L. TAYLOR.
A Line O' Type or Two.
Chicago Tribune, 1918 Jan. 7.